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Municipal Socialism.

A SERIES of articles now appearing in the *Times* on this subject bears a strong family resemblance to former articles on "American Engineering Competition" and a "Crisis in British Industry". The present series, like its predecessors, is chiefly remarkable for the presentation of facts and figures in overwhelming profusion, for the avowed purpose of proving that existing methods of municipal government are the result of socialist doctrines and influence, and that these constitute preliminary steps to the "collectivist state." Unfortunately, the *Times* correspondent appears to be an enthusiast who tries to prove too much, and fails to present his facts in the most advantageous form. As a catch-word, "Municipal Socialism" may have been useful during the holiday months, but its employment has not been justified by the articles to which it was applied. Nevertheless, the series in question has been of much interest to all classes of the community, and we fully believe it has done something to show the general public how largely municipal enterprise is overstepping its proper boundaries, and how extensive are the ramifications of municipal extravagance and mismanagement. No one who is moderately observant can avoid the conclusion that corporations and councils of all classes are widely exceeding their legitimate functions, and are adding recklessly to local indebtedness and taxation.

Municipal trading is becoming more and more developed throughout the country, and in some places it constitutes, directly and indirectly, a serious threat to industries upon which the prosperity of the populace largely depends. Municipal enterprise affects private enterprise in various ways; by offering similar services at unremunerative, and therefore lower rates; by increased taxation consequent on trading losses; and by selfish opposition to improved services promoted by independent enterprise.

Few local government bodies adhere to their proper duties of providing merely for the health and safety of citizens. A widely extended view is now taken of municipal responsibility. To take Glasgow as an example, we find the corporation undertake gas, electric light, tramway and telephone services; they control 11 public parks and galleries, 13 baths and wash-houses, 8 markets devoted to the sale of fruit, vegetables, cheese, dead meat, cattle, birds, dogs, and old clothes, 4 slaughter-houses, 4 hospitals and 1 cemetery; and in addition to the buildings mentioned they own over 3,000 others, including houses, shops, workshops, factories, warehouses, public halls, churches and theatres; they also provide a golf course, farm over 1,000 acres of land; they are engaged in market gardening, stone quarrying, in the management of a municipal granary, and in the conduct of various other trades which need not be specifically mentioned.

Probably there is no city in the Kingdom with more extended views of municipal policy than Glasgow, but it may be useful to note some of the more unusual developments in the way of trade that are evidenced in other places. Feeding-bottles and milk for babies are sold by the St. Helens Corporation, saw mills are conducted by the authorities of Cardiff and Battersea, the businesses of wagon building and brush making are carried on by the Manchester Corporation; and not content with the sale of gas stoves, the Birmingham Corporation unblushingly tout for trade as jobbing gas-fitters in unfair competition with struggling tradesmen. Some public bodies would like to go further afield, as shown by proposals to

start municipal tailors' shops, printing and bookbinding works, to undertake plumbers' and kindred work, and to buy up and work coal mines on a communistic basis.

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The question as to what constitutes trading on the part of a municipality is variously answered. Taking the most conservative view, it may be said that the permissible function of any local government is to provide good drainage and water-supply systems, to make and maintain streets and roads, to sweep the streets, to supervise building operations, to prevent nuisances or other conditions prejudicial to health, and to discharge such duties as are not associated with the earning of revenue, and are necessary for the well-being of the whole community. According to moderately progressive views, the establishment of gas, electric light and tramway systems are legitimate, and enterprise in these directions is supported on the grounds that the services, being for the general good, ought to be managed by the representatives of the community, instead of by profit-earning monopolists. It is also urged that, as the systems in question are so intimately connected with the making and upkeep of streets and roads, they legitimately belong to the province of municipal work. There is something in favour of this contention, but as we shall presently show, there is a good deal against it.

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Speaking generally, municipal trading, as it exists to-day, involves illegitimate interference with the manufacturer and tradesman by disregarding the recognised principles of fair competition; it is a direct obstacle to industrial progress, and takes away the incentive to enterprise of the kind which has so largely contributed to the greatness of the British Empire. It is hard enough for home industries to fight competition supported by foreign governments, but it is a refinement of injustice that they should be called upon to provide money for the inauguration of competitive trading by domestic governments.

An idea of the magnitude of the operations conducted by local government authorities may be obtained from the fact that the municipal debt of the country has been increased by the sum of £183,000,000 since the year 1874, and now stands at more than £300,000,000. Again, local taxation has increased from £17,000,000 in 1869, to £38,000,000 in 1899, and an average increase of 1*s.* in the pound has taken place since last year. In themselves, the figures we have quoted may not serve to show that industry is being suppressed, for it may be argued that the vast extension of sanitation and education during the periods mentioned may well account for these large increases. Unfortunately, it is the fact that much of the expenditure relates to purely speculative business on the part of public bodies, and, further, that Acts of Parliament are strained for the purpose of unwisely extorting money from traders, to the ultimate detriment of the community. For instance, the rating of machinery is being carried to the most absurd lengths by corporations who must find money by hook or by crook to pay for their expensive hobbies, and who prefer to extract large amounts from a small, rather than from a large number of voters. We have known cases where the excessive rating of new machinery has taken away at once all the advantage expected by the manufacturer as the return for his outlay. Other cases could be cited where the rates on small house property are kept down to conciliate the working-man voter, while the assessments on business premises are raised to counterbalance the loss, and at the same time to pay for the luxuries promised to the working man as the price of election.

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With the object of showing more definitely what is the effect of municipal trading upon local industries, we will give one or two concrete examples. Let us take the borough of West Ham as an example, where out of some 45,000 assessments not more than a fourth exceed the value of £20. It is therefore clear that the only means of providing money for the utopian schemes of the corporation is to bleed the manufacturing classes as heavily as possible. Consequently assessments have been increased on the

flimsiest of pretences. Any improvement intended to meet new requirements of trade or to give employment to more men, and every new tool or machine introduced, has been followed by increase of assessment. So unbearable has this system of persecution become that several large firms are already removing their works to other districts, and in more than one case work is being transferred to Continental works, where the Government and local rates of taxation are not more than 10 per cent. of those demanded at West Ham. The Great Eastern Railway works are assessed at about £100,000, and the burden of taxation is such that the removal of the works to some less "enterprising" locality has already been under consideration. As the works find employment for 5,000 men, their removal would be a considerable blow to the prosperity of West Ham; and the general migration of oppressed manufacturers would bring about a time of rude awakening for those ignorant councillors who are now so busy spending on the working man the money extorted from industrial works.

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So far as railway and other large companies are concerned, the burden of excessive taxation really recoils upon commercial interests throughout the country, as well as upon the shareholders, for every railway company is obliged to regard local taxation as a preponderating factor in the calculation of rates for passengers and merchandise. To show how enormous is the disproportionate increase in this direction, it may be mentioned that returns furnished by thirty-nine railway companies prove the increase of taxation since 1891 to be no less than £1,587,000, representing about 73 per cent., although the capital of the same companies has only increased by 20·7 per cent. and the gross receipts by 26·37 per cent. These figures include taxes as well as rates, but to give some idea of the increase in parochial rates alone we may state that one of the largest London companies paid £199,429 in 1901 as against £102,642 in 1891, an increase of £96,787. No doubt considerable additions were evidenced in the company's system during the period involved, but the increase of rating was chiefly due to the disproportionate increase of assessments, this being proved by the fact that the amount demanded in 1901 was £19,428 more than that asked for during the previous year. The direct effect of extortion of the kind is to discourage railway companies from the inauguration of improvements. As the chairman of the Great Eastern Railway Company remarked on a recent occasion, if the company were to yield to demands for a new station in any given locality "the assessment on it would go up like a rocket." This mistaken policy of handicapping railway enterprise pervades the whole country, and local authorities everywhere regard the companies as their legitimate prey. We fully admit that railways ought to pay a proper share of the cost involved by provision for the health and security of the people, but it is not just that they should be taxed for the purpose of providing municipalities with funds to squander on luxuries or to venture in speculative trading.

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Dock companies are in a very similar position, for they must increase charges in proportion to the augmentation of assessment and rating, to the ultimate detriment of traders and consumers. Taking the chief docks in the London district, we find that one company was compelled to pay £101,116 in 1901, or £42,000 more than that demanded in the year 1891, and that the bulk of this increase is accounted for by increased assessments. The contribution of the same company to the School Board rate of West Ham alone amounts to £6,000, representing nearly 2¼ per cent. on the deferred ordinary stock of the company.

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From what we have already said, it must be sufficiently clear that most serious injury is being done to the industrial interests of the country by excessive taxation, the proceeds of which are devoted either to municipal extravagance or to the conduct of trading concerns calculated to injure those carried on by the classes who provide the money.

In our next issue we propose to call

attention to other aspects of municipal "enterprise," and especially to its influence on electric light and tramway undertakings.

Electric Power Transmission.

GENERALLY speaking, electricity employed as a motive power is still a comparatively new thing to the works manager and engineer. In Great Britain we have not been sufficiently ready to accept the indisputable advantages offered by the transmission of power by electricity. Low-pressure steam boilers and antiquated steam engines are retained as treasured possessions in numerous factories, and small engines of wasteful type, fed by long runs of pipe, leaking "coal" through every foot of their mileage, are still to be seen in many large industrial establishments. Even in the distribution of power to the individual machines contained in a shop, little heed is given to the enormous waste due to the employment of shafting and its accessories. No doubt such examples as these were before the mind of Professor Perry when he spoke to the members of the British Association in these words:—

"The ordinary type of old-established works, where gradual accretion has produced a higgledy-piggledy set of shops which one looks at with stupefaction, for it is impossible to get business done in them well and promptly, and yet it seems impossible to start a reform anywhere. What is wanted is an earthquake or a fire—a good fire—to destroy the whole works and enable the business to be reconstructed on a consistent and simple plan."

It is not invariably the case that a works requires to be "scrapped," as suggested by Professor Perry in the course of his ebullient address, for there are many establishments where comparatively trifling re-arrangement of machinery and the substitution of electric for mechanical power transmission would put things on a businesslike and efficient basis. Sufficient data are now available, and are to be found in our columns, to prove the enormous advantages derivable from the employment of electricity in this manner. The saving of labour is one most important item, and the reduction of coal consumption is another equally worth the notice of manufacturers. Incidentally, the economy effected in connection with the use of coal would be of benefit to the country at large, for it would defer the anticipated day when the coalfields, our most valuable national asset, shall be finally exhausted. Again, the enormous reduction in the volume of smoke generated and the concentration of smoke-producing plants consequent on the general use of electricity and the establishment of large power stations, would inevitably improve the hygienic condition of large industrial centres throughout the land.

The adoption of electric power in the manufacturing industries of Great Britain has certainly commenced, but its growth is in no way commensurate with that evident in the United States and on the Continent. The reluctance of people in this country to believe in and to adopt any new thing until some one else has tried it, is no doubt largely responsible for the small progress of electric power transmission. If the railway engineer, who is supposed to be a specialist in the effective and economical application of power, has only lately begun to realise the possibilities of electricity, we cannot wonder that the engineer with smaller pretension to scientific knowledge, and the manufacturer without any such qualification at all, should still pin his faith to the steam engine and mill-gearing which were good and faithful servants of their fathers. We are not now dealing with the question of electric traction, and the railway engineer is merely mentioned as typical of national diffidence, and, we fear it must be added, inexcusable ignorance. There is some excuse for lack of enterprise on the part of a manufacturer, but not on the part of the manufacturing engineer. No doubt, the proprietors of many industrial concerns are unskilled, and are, therefore, obliged to rely largely on the assistance of managers having the necessary technical knowledge and experience. But even in such cases, the managing engineer has very limited powers and responsibilities. In America, a different

state of things obtains, for much greater latitude is given, with the result that improvements are rapidly carried out, and the proprietors look to the manager for savings, as a result of his personal acquaintance with the details of any scheme put forward by him. In our own country little initiative is permitted to the manager of an engineering works, and almost every innovation must first be approved by the proprietors. When the business is one of old standing, and the partners or directors have been brought up to regard it in the light of a glorious inheritance, it is a very difficult thing to persuade them to alter anything, and especially difficult to convince them as to the advisability of making a change so drastic as the substitution of electricity for steam. Of course, these remarks only apply to the majority of the industrial firms in this country; and we are happy to say that there are many establishments in which the advantages possessed by electricity for the transmission of power have been fully recognised. Our object is to bring home to unadventurous spirits that it is necessary in the present day to swim with the flowing tide of progress, and to make clear the futility of clinging timidly to old methods, which are bound to be swept away at no distant date by the advancing flood.

The Coal Strike.

WITH the happy ending of the American coal strike one of the most remarkable struggles of the age has been brought to a close. Commencing in May last, this war between capital and labour has paralysed industry in the United States and caused serious inconvenience in other lands. The Wyoming Valley—the centre of the strike—became as though stricken with death, nearly 50,000 miners left for other regions, factories were closed for want of fuel, steamship freights were so raised as to cripple various industries, and the fruit growers of one State alone lost millions of dollars owing to the lack of fuel for evaporative purposes. In New York anthracite coal rose to the unparalleled price of four guineas per ton; terra-cotta bricks soaked with oil were used in some places as a substitute for coal, and in Chicago the people tore up wood pavement for use as fuel. The general loss to the community up to the end of the strike is estimated at a sum little short of thirty million pounds, and arrears of coal production will probably not be overtaken until after the winter now approaching.

It may be that the coal miners of the United States are paid less money than they would like to receive, or than their leaders tell them they ought to get; but it has not yet been proved that their pay was inadequate. Mr. Mitchell, their leader, suggests that the strike was only inaugurated "after every possible means had been resorted to in order to secure an adjustment of grievances by conference, conciliation, and arbitration." We ought to add that this statement occurs in an appeal for money addressed to British trades-unionists; and if we may judge Mr. Mitchell by his treatment of the proposals afterwards made by President Roosevelt, it seems very unlikely that any reasonable attempt was ever made by him towards an amicable settlement. It is one great evil of trades-unions that the leaders are directly interested in raising up and maintaining strife, so that these paid agitators are really the worst enemies of the men, as well as of employers. Let us see what happened when the President endeavoured to bring about an agreement.

Mr. Mitchell positively declined to advise the men to return to work during investigation of their claims by a committee to be appointed by the President; he absolutely refused to accept the proposal to submit individual grievances to the Courts of Common Pleas in Pennsylvania; he raised obstacles to every proposal made; and seemed to be actuated by foolish pride in the strength of the union, saying "Our forces are united, and the strike cannot be broken." It is a strange thing that 170,000 miners, with women and children making up a total of some 500,000 persons, should place them-

selves at the mercy of one man, their paid servant; and still more strange that they should give him absolute power for stirring up strife but no authority for making peace. We do not suggest that the coal-owners were altogether in the right As members of a gigantic trust, they may have been too confident in the power of capital, which is capable of abuse just as much as the power of labour. The President also approached the capitalists with an appeal, which finally resulted in the acceptance by them of a commission to decide all questions at issue. They further agreed in advance to accept the decision of the commission as binding, stipulating only that the miners should resume work at once, and that the finding should govern the relations of masters and men for at least three years. This is a very straightforward arrangement. The owners strongly objected to bargain with the Union leaders, or to make any settlement which would not secure to all men, whether unionists or non-unionists, the right to work or not to work when they chose. By placing themselves unreservedly in the hands of an independent tribunal, the owners put themselves right with the general public.

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Mr. Mitchell seems to have received the announcement with bad grace, evidently thinking more of his own self-importance than of thousands upon thousands his obstinate folly had reduced to starvation; he was indignant because no official recognition was offered to him. He cared as little for the suffering public, and threatened to stand out for his position as sole intermediary between the men and their employers. This heartless effrontery was of no avail with the strong man who had taken up the negotiations. He gave way, and the strike was at an end. This brings us to President Roosevelt's share in this stupendous struggle. He did not enter upon it after the fashion of those benevolent but weak persons who sometimes come forward in this country to calculate the mathematical mean between the extreme claims of masters and men. Mr. Roosevelt knew what he was about, and he was quite prepared to show either side that he was not to be trifled with. What was the nature of the pressure he put on Mr. Mitchell we do not know, but its immediate effect was an unconditional surrender. No doubt the success of his previous dealings with the employers placed a powerful lever in his hand. In these negotiations he was aided by the determination of the Government to take prompt and decisive action for averting a national catastrophe. It is believed that the measures approved by his Government involved the proclamation of martial law in the disaffected region, the attachment of all mines, and the mining of coal under State supervision.

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There is a refreshing vigour about this scheme which must commend it to all men of spirit. It marks the vigour of a born ruler backed up by a strong Government, and it directs our thoughts at once to the only other constitutional ruler in the world from whom a similar display of strength could be expected. President Roosevelt has done a great thing; he has proved himself worthy of being placed alongside of those kings and emperors of times gone by who knew what they wanted and knew how to get it. He has prevailed over the powers of evil in the shape of extravagant combinations both of capital and of labour, and has set an example that is well worthy of imitation. The American coal strike will undoubtedly result in much good, if it causes legislators to realise the tremendous powers for evil that have been acquired by ignorant and misguided men. Trades-union organisations have been allowed to permeate countries, creating potent though unwritten laws, while Parliaments look on, feeble and timorous, without attempting to provide necessary safeguards for protecting the interests and liberties of the people at large. In our own country we are spared the disgraceful episodes which characterised the recent strike in the United States, but the hand of unionism is heavy on every industry, and the whole system is one that requires immediate revision on reasonable and equitable lines by a strong and capable Government.

Original Signed Articles

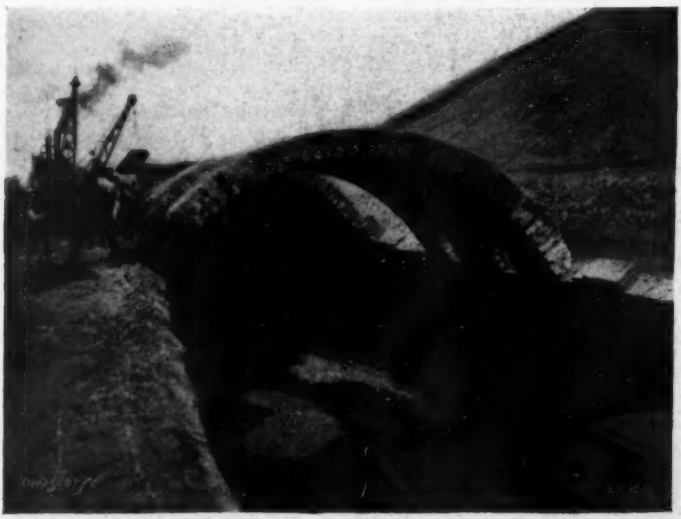
Demolition of the Bugsworth Tunnel.

By GEO. C. MACDONALD, M.Inst.C.E.

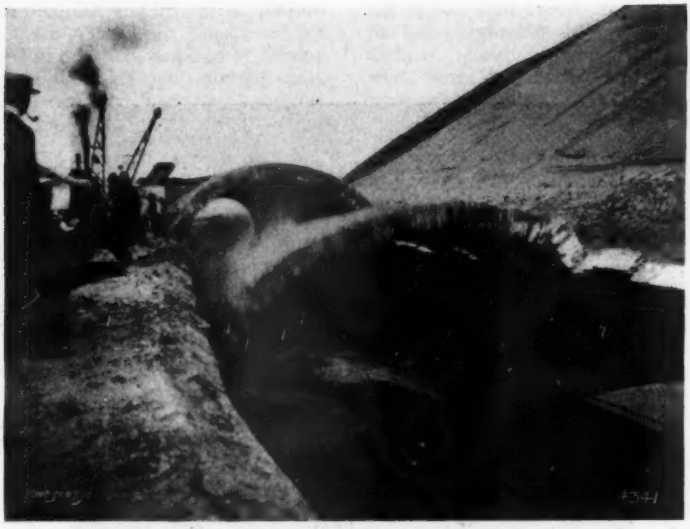
NOWADAYS, when nearly every railway company is widening its main lines, many of the old bridges have been taken down or altered; but it is very seldom that a tunnel is interfered with. A somewhat interesting case, however, has just occurred at the small village of Bugsworth, on the Derby and Manchester line of the Midland Railway, of the demolition of a tunnel, a short description of which may prove of interest. The railway at this place was constructed in the year 1865, and was carried through a short and very steep spur of the adjoining hill in a tunnel 264 yds. in length. A widening of this line

FACE OF TUNNEL, SHOWING CUTTING DOWN TO CROWN OF ARCH.

TOP OF TUNNEL ARCH, SHOWING CROWN BARS LEFT IN.



20-FT. SECTION READY FOR DROPPING. THE ADJOINING SECTION BEYOND HAS ALREADY FALLEN.



SECTION OF ARCH FALLING.

SECTION OF ARCH FALLING, SHOWING PORTION KICKING BACK ON TO SIDE WALL.

SEVEN SECTIONS READY FOR DROPPING

is now in progress, and for several reasons an open cutting has been substituted for the tunnel in question, in place of driving another one alongside. As a consequence, the tunnel was literally dug out and the whole of the old work exposed. The hill is entirely of sand, with a very steep slope at right angles to the railway, and had a height above the rails of some 85 ft. Considerable difficulty was reported to have been met with when the railway was made, owing to the presence of water in the sand, and the truth of this has been amply borne out by the appearance of the tunnel when exposed, as every scrap of timber used was built in. The crown bars presented a very extraordinary appearance, lying along the top of the arch when opened out, and are well shown in the photograph. They were quite spongy and decayed for a depth of some inches all round, but fairly hard in the middle, although all the nature of the timber was gone. The poling boards had practically entirely disappeared, nothing but the impressions of them in the sand being found. The tunnel arch was formed of eight rings of brickwork in lime mortar on masonry side walls, and proved to be a very sound piece of work throughout, although somewhat distorted in places where, evidently, great pressure had been met with during construction. The cutting was taken out to within a few feet of the crown of the arch by means of steam navvies, without any special precautions, but care was then taken to excavate the sand from the haunches equally on both sides. The cutting proved to be perfectly dry, owing, no doubt, to the hill having been drained by the tunnel. When the sand had been removed to the springing of the arch (10 ft. above rail level), the latter was taken down in the following manner. Four of the eight rings of brickwork were stripped off, and chases 2 ft. wide cut transversely to the tunnel through the remaining four rings, 22 ft. centre to centre, thus dividing the arch into sections 20 ft. long. In each of these sections holes or "windows" about 4 ft. square were cut through close down to the springing line, two on each side, leaving each 20-ft. length standing on six legs of brickwork 4 ft. wide. All this work was done on week-days, without in any way interfering with the very heavy traffic passing through the tunnel. On Sundays entire possession was taken of the roads for as long as the traffic permitted (the longest interval being usually about two hours), and each section of arch was dropped by knocking away the supporting legs of brickwork on one side only with hammers and wedges. The *débris* was picked up by steam cranes working on the top of the side walls. The brickwork held together in the most wonderful manner, each section seldom dropping until the very last brick had been knocked away. A sharp look-out had to be kept by the men at work at the instant the arch fell, as portions sometimes kicked back on to the side walls instead of falling into the bottom. A very good instance of this is shown in one of the photographs. The whole of the tunnel, however, was taken down without a single accident of any sort occurring. The longest length dealt with on one Sunday consisted of seven sections, which, with the chases previously cut, represented 51 yds. of tunnel. The side walls were removed gradually on week-days without interfering with the traffic.

George C. McDonald

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The Analysis of Trial Trip Data of Steamships.

By H. BEAUMONT DONALDSON.

THE importance of scientific investigation of shipbuilding and engineering problems is universally recognised by every progressive individual, but, in this country, does not meet with the practical recognition which is necesssary for us, as a nation, to keep abreast of our foreign rivals.

Our supremacy as an engineering people is being assailed with great vigour by German and American competitors, who, with commendable foresight, are not content with turning out work which has a satisfactory external appearance, but probe into its most abstruse aspects, with the result that they are able to ascertain what return they receive for their expenditure, and are in a position to put past experience to a useful purpose in future work.

In our own country valuable investigations have been carried on by the late Mr. Froude, to whose vast researches in the field of ship propulsion and the kindred subjects we owe a great amount of our present knowledge.

Foremost among present-day investigators are Messrs. R. E. Froude, S. Barnaby, C. Parsons, Yarrow, Thornycroft, and the Dennys. Beyond these men, there are very few who give time or thought to the scientific branch of their occupation; the commercial side seems to possess, for such, the sole attraction.

The methods adopted by very many firms for estimating the amount of power requisite to drive a certain ship at a given speed, displays at best a very imperfect and rudimentary knowledge of this all-important feature of ship-designing. By means of the Admiralty constant method a power is arrived at, giving, in most cases, an amount considerably in excess of what is actually required, thus involving unnecessary outlay. A knot, or fraction of a knot, in excess of the designed speed, is looked upon as a triumph, whilst to right-thinking minds it is as much an error as a knot below the stipulated speed.

In order to estimate the power with any degree of accuracy, it is necessary to have a thorough knowledge of the manner in which the power indicated in the engine is expended throughout the mechanism; for this purpose a careful analysis of trial trip data is essential. The manner in which power is absorbed as it leaves the engine is illustrated by Fig. 1.

In the first place, before a reasonably fair analysis can be made, it is absolutely important that the data taken be of the most complete and accurate description. All conflicting influences, such as wind and tide, must be eliminated from the calculation, so that the net result may be the same as though the ship had been tried under conditions where there were no external influences to interfere with the progress through the water, and a steady supply of steam kept up to the cylinders throughout the trial, as any jockeying would convey very misleading impressions and give entirely incorrect and unreliable data.

Reverting to Fig. 1, the first absorbent of power is the initial friction, with which is included the power of any attached pumps. In the present-day marine engine, the air, circulating, and bilge pumps are usually driven off the main engine.

Friction depends solely on the material and condition of the surfaces in contact, and is entirely independent of speed, assuming that of course the temperature of the material remains constant throughout the varying speeds. Therefore the amount of power lost through "initial friction" varies directly with the revolutions.

The writer obtained the I.H.P. curve of the United States gunboat *Bancroft*, which appeared in the Transactions of the

American Society of Naval Engineers, Vol. V., and has analysed it for the purposes of illustration. The over-all dimensions are:—Length, 180 ft.; breadth, 32 ft.; draft on trial, 11 ft. 5¼ ins.; displacement on trial, 832 tons; wetted surface, 6,150 sq. ft. It is driven by twin screws, each worked by an independent set of vertical inverted triple expansion engines.

Cylinders, $\frac{13\frac{1}{2}'' \times 21'' \times 31''}{20''}$

In this case an initial pressure of 2·05 lbs. per sq. in., referred to the low-pressure cylinder, is necessary to overcome the initial friction. On Fig. 2 is the h.p. curve, with the frictional h.p. deducted (Curve 2). The amount of h.p. wasted is obtained by multiplying the initial pressure by an engine constant, obtained from the size of the low-pressure cylinder, and by the revolutions for the different rates of revolutions.

On Fig. 3 will be seen the curve of h.p. of a torpedo boat destroyer, absorbed by initial friction obtained by running the engine uncoupled. This curve does not denote a constant increase directly as the revolutions, but shows an upward tendency, thus indicating that there is a slight increase in the initial friction with an increase of revolutions.

On the same figure is the curve of mean pressures necessary to overcome the initial friction at different rates of revolutions. The character of this curve does not seem to fulfil general expectations. At first it gradually drops, showing a slight decrease up to 230 revolutions, then it assumes an upward tendency. The reasons which may most naturally be assigned to this variation are, that at first the adhesive properties of the lubricant are gradually lessened until it almost disappears; then, owing to the increased speed, after 230 revolutions the bearing surfaces become slightly heated, thereby involving expansion, which however slight must show on a curve of this kind.

It is quite permissible, however, to assume that this initial pressure is a constant factor.

Suppose in this case we assume it to be a constant of 2·7 lbs. per square inch, the effect on the horse-power curve is very slight, as shown by the dotted lines. So that for all practical purposes it may be assumed that the variation is constant with the revolutions.

The necessity for good workmanship is obvious, as bad-fitting pistons, piston-rods, slides, bearings, etc, or any rough bearing surfaces will cause heating, involving expansion to take place more or less quickly, thereby unduly increasing the frictional horse-power.

As a graphic example of how this drain on power may vary for different ships of different types, or even for ships and engines of exactly the same type, two sister ships were analysed by the late Mr. Froude, the results of which appear in the *Trans. Inst. Naval Architects*, 1879.

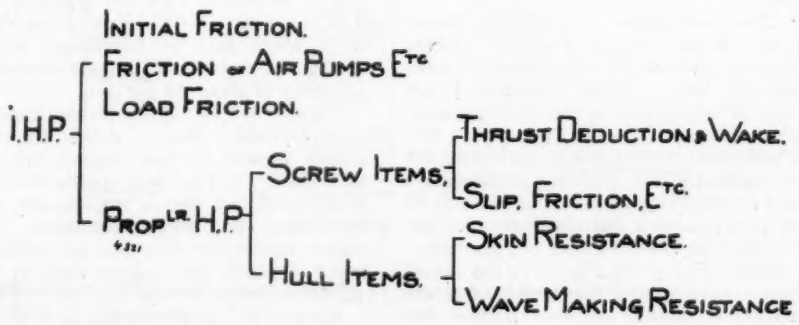


FIG. 1.

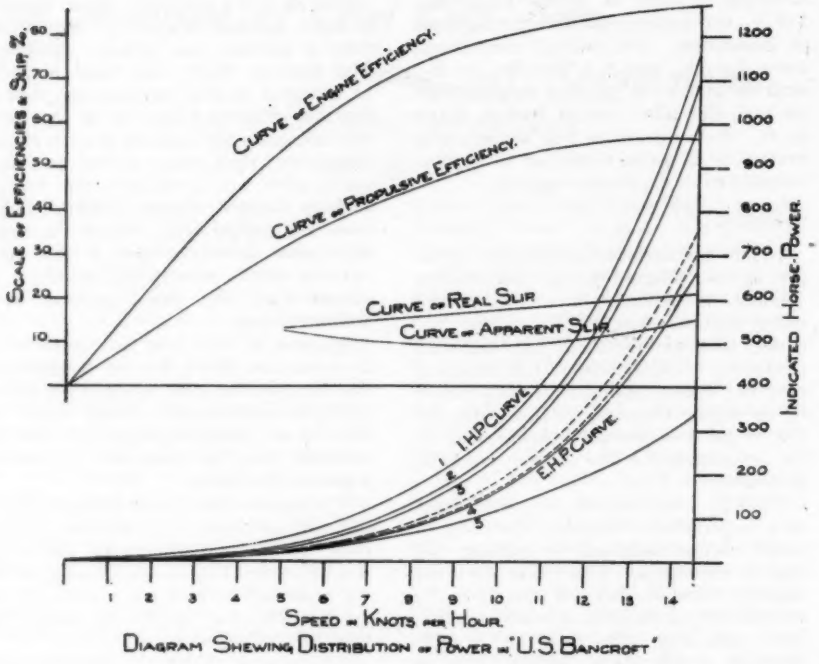

Scale of Efficiencies & Slip %.
Curve of Engine Efficiency.
Curve of Propulsive Efficiency.
Curve of Real Slip
Curve of Apparent Slip
I.H.P. Curve
E.H.P. Curve
Indicated Horse-Power.
Speed in Knots per Hour.
Diagram Shewing Distribution of Power in "U.S. Bancroft"

FIG. 2.

In one ship the initial friction exceeds that of the other by about 50 per cent. They were exactly similar in ship and engine dimensions, being also built by the same firm.

The next drain on indicated horse-power is the "Load Friction." There are very few reliable experimental results for this loss. Taylor considers 7 per cent. of the net horse-power to be a reasonable allowance, while the late Mr. Blechynden, in a paper read before the North-East Coast Institute of Engineers and Shipbuilders, in 1886, considers $6\frac{1}{2}$ to $7\frac{1}{2}$ per cent. as a fair allowance. A fair standard on which to work is 7 per cent.

Curve No. 3 on Fig. 2 is the horse-power curve after the horse-power absorbed by initial and load friction has been deducted.

The requirement of an efficient thrust-block is a point of paramount importance, and careful consideration should be given to this necessary feature of the engine.

Fig. 4 shows curves of standardised engine efficiencies for a few typical ships. The curve marked "C," that of the *Bancroft*, which may be considered a fair average for war vessels, shows a maximum efficiency of about 88 per cent.

Curve "D" is for the Italian armour-clad *Lepanto*. She is driven by twin screws worked by four engines, two on each shaft. At the lower speeds the ship is driven by two sets of engines only, the remaining two being uncoupled. At higher speeds the four sets are utilised, which explains the sudden drop in the efficiency curve.

Curve "F" is interesting, as it is the curve of efficiency of the S.S. *Merkera*, a vessel built some twenty-five or thirty

years ago, and analysed by the late Mr. Froude. An account of this analysis appears in the *Trans. Inst. of Naval Architects*, Vol. XVII. It shows very graphically the rapid strides which have been made in the last generation.

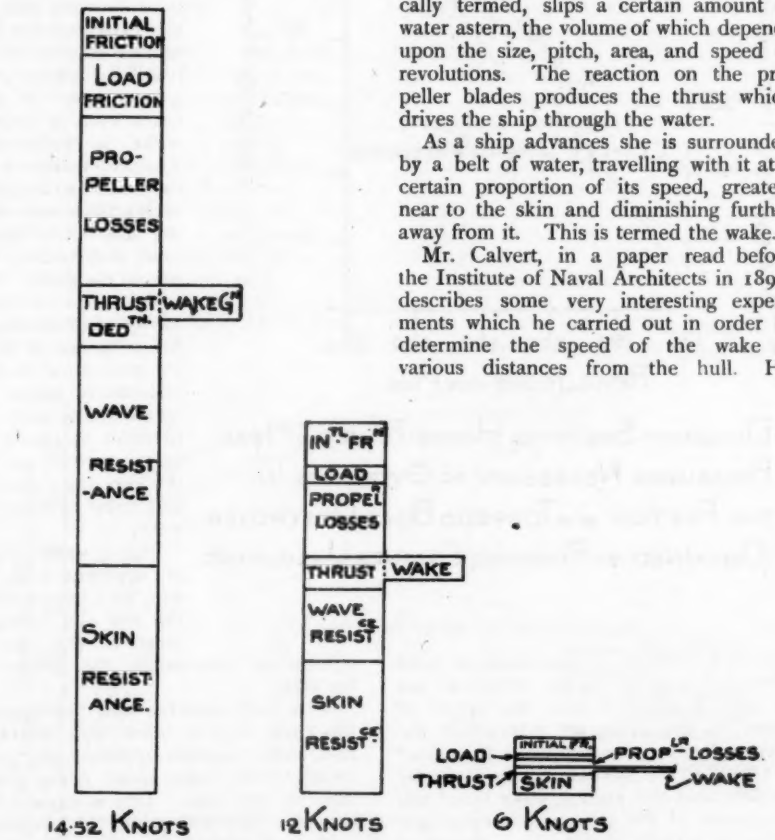
For ships which have engines driving attached pumps, the efficiency is, of course, somewhat lower, as illustrated by curve *E*.

The remaining power—*i.e.*, between curve of load-friction and bases on Fig. 2—is the actual amount which reaches the propeller, and it is here where the most abstruse and complicated item of the analysis presents itself.

The problem would be an exceedingly simple one if the principle was the same as that of an ordinary screw being driven into an unyielding medium. Instead of this the propeller impels or, as is technically termed, slips a certain amount of water astern, the volume of which depends upon the size, pitch, area, and speed of revolutions. The reaction on the propeller blades produces the thrust which drives the ship through the water.

As a ship advances she is surrounded by a belt of water, travelling with it at a certain proportion of its speed, greatest near to the skin and diminishing further away from it. This is termed the wake.

Mr. Calvert, in a paper read before the Institute of Naval Architects in 1893, describes some very interesting experiments which he carried out in order to determine the speed of the wake at various distances from the hull. He



GRAPHIC REPRESENTATION OF DISTRIBUTION OF POWER AT VARIOUS SPEEDS

FIG. 2A.

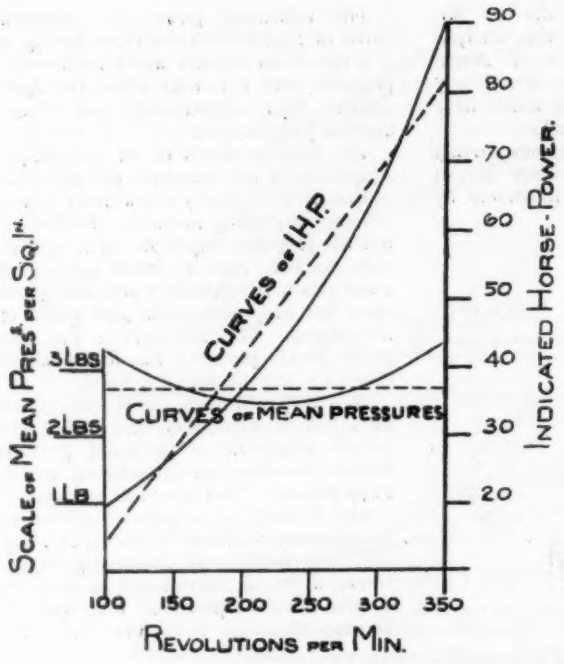


DIAGRAM SHEWING HORSE-POWER & MEAN PRESSURES NECESSARY TO OVERCOME INITIAL FRICTION OF A TORPEDO BOAT DESTROYER OBTAINED BY RUNNING ENGINES UNCOUPLED.

FIG. 3.

placed a number of glass tubes at fixed distances from the model, which he ran at various speeds: from the height of water in the tubes he determined the wake velocity at the respective distances.

Owing to the forward motion it will be evident that the average wake speed will be greater at the stern, so that the propeller is actually working in a stream of water which is following the ship at a certain proportion of its speed, depending on the distance from it. For all practical purposes we may assume that the speed is constant, and the propeller is working in a forward stream of a uniform velocity, and therefore is gaining a certain amount of power from it.

In ordinary merchant ships a 20-per-cent. wake is of common occurrence. In modern battleships it varies from 9 to 10 per cent., whilst in destroyers, owing to the extremely fine lines of this class of vessel, it falls as low as 1·7 to 3·5 per cent. In some cases even a negative wake is experienced. The only reasons which the writer can assign for such a phenomenon are the fine lines, shallow draft, and cut-away portion of the stern.

The apparent slip is the speed of advance of the propeller as found by multiplying pitch by revolutions minus the speed of the ship; but in order to obtain the actual amount of slip, or true slip, must be added the speed of the wake.

Fig. 2 shows curves of apparent and real slip for the *Bancroft* the real slip being, as must be the case for economical propulsion, the greater of the two.

It is quite possible that the apparent slip curve may in some cases fall below zero, and a negative apparent slip result, owing to the wake speed being greater than the real slip. This is caused by a low true slip, with which is inseparably associated low efficiency, entailing great waste of power.

It will now be seen that the propeller is working in a stream of water having a forward motion imparted to it, with the result that a certain amount of power,

which is expended in maintaining the wake, is compensated for by the decreased number of revolutions, and, in consequence, of power, compared to what would be necessary assuming the ship caused no wake. Against this must be set, however, the loss caused by the increased velocity of water as it journeys towards the propeller, producing a defect of pressure on the stern. This additional source of resistance is termed the "Augmented Resistance," or "Thrust Deduction."

The ratio of wake gain to thrust deduction is termed "Hull Efficiency," and, as may be seen from the curves, very nearly approaches unity, the value for the *Bancroft* being ·95. It averages from ·94 to ·98 for boats of ordinary proportions. In some shallow-draft vessels, built with the Thornycroft pattern of stern, where the water in the propeller channels is all wake water, the hull efficiency rises to as much as 101·2 per cent. This, however, is of extremely rare occurrence, and no great error is caused if the efficiency be taken as unity.

A large proportion of the power which is delivered to the screw is wasted by surface friction. In order that this may be kept as low as possible, the propeller blades should have a smooth surface, so as to minimise this amount of waste.

Froude, in his experiments on screw-propellers, has found that for a given propeller working under given conditions there is a certain area ratio, beyond which any increase the thrust obtained will not justify the proportions. An area ratio may be reached, indeed, which will show an actual diminution in efficiency due to the abnormal increase of frictional resistance. Curve No. 4 on Fig. 2 shows the amount of horse-power which is utilised by the propeller in driving the ship through the water, and is called the effective horse-power. In close proximity to this curve, however, will be seen two others, indicated by dotted lines. The ordinates between the curve of E.H.P. and the upper dotted curve represent the amount of power lost by thrust deduction. This loss is very nearly counteracted by the amount of power gained from the following wake.

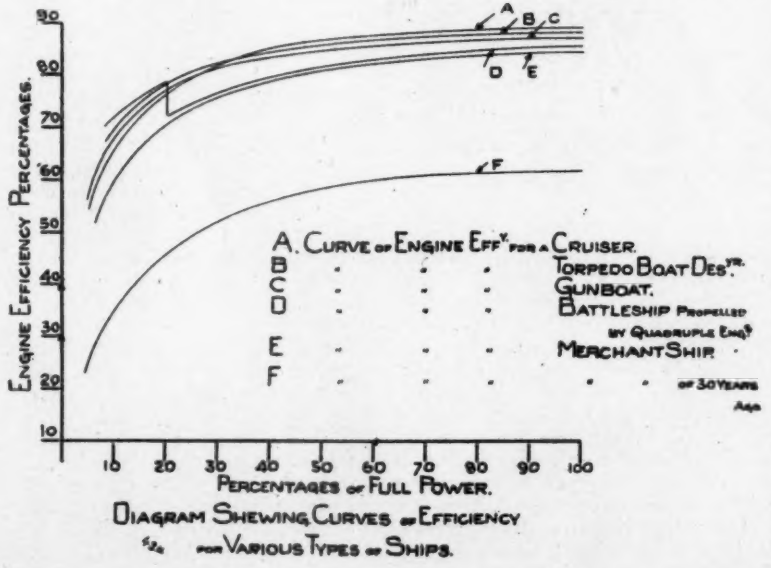


Diagram Shewing Curves of Efficiency for Various Types of Ships.

FIG. 4

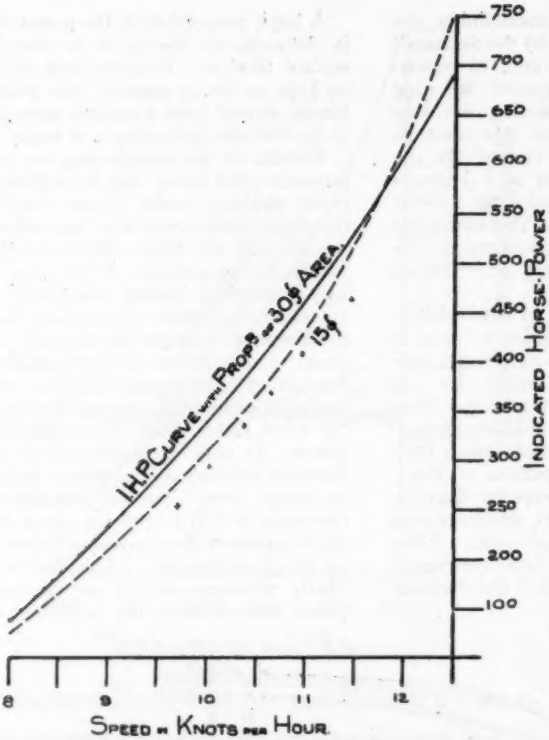


DIAGRAM SHEWING CURVES OF I.H.P. FOR A MERCHANT SHIP SHEWING THE EFFECT OF PROPELLERS HAVING DIFFERENT AREA RATIOS.

FIG. 5.

This amount is indicated by the ordinates between the two dotted curves.

The lower dotted curve is the actual thrust exerted at the thrust block. The ratio between e.h.p. and i.h.p., as before explained, is termed the hull efficiency. The difference between the two curves is seen to be very small. At ordinary cruising speeds, say from ten to twelve knots, it never exceeds two per cent.; at fourteen and one-half knots it increases slightly to about three per cent.

This analysis bears out the assumption that hull efficiency may be taken as unity. The remaining power between the curve of E.H.P. and base is the actual amount utilised in overcoming the ship resistances, namely, skin and wave-making.

The ordinates from base to curve No. 5, represent the skin horse-power, and between curves Nos. 5 and 4 the horse-power utilised in overcoming the energy necessary to maintain wave formation, so inseparably associated with the higher speeds. Up to six knots the skin friction is the sole drain on the E.H.P., but from this up to full speed the wave-making propensity of the ship makes itself apparent. In long ships of from 400 to 500 ft., the wave resistance is not appreciable until about eight knots are reached, but, owing to the less length of the *Bancroft*, it is experienced at lower speeds.

On Fig. *2a* are shown diagrams for speeds of 6, 12, and 14·52 knots of the *Bancroft*, giving the subdivisions of the components making up the total horse-power. This indicates very clearly the proportions in which the different losses increase with increase of speed.

In most modern merchant ships the bilge, air, and circulating pumps are driven off the main engines, causing a greater loss, owing to the extra friction thereby entailed.

In warships, on the other hand, the pumps are usually all separate, and are driven by independent engines. For ships where pumps are driven off the main engines at full speed, about 20 per cent. of the power is lost through initial friction, and where they are independent about

15 per cent. may be taken as a fair average.

The need for such an analysis of the description described cannot be too fully emphasised. As was remarked at the introduction of this paper, competition is so keen and margins for profit have been cut down to such small limits, that any one of the many working parts, which make up the whole machine, performing its duty in a wasteful manner may make serious inroads on the profits; and this is the only manner in which the efficiency of each part, and consequently the whole, can be arrived at.

It is not an unusual occurrence to hear of a ship which has on trial developed the expected I.H.P. but has failed to reach the desired speed. Of course the blame falls on the ship. There is some vague talk of something being wrong with the lines, or some other possible or imaginary loss. As a matter of fact, if a careful examination were made of the power as it left the engines, some surprising results would probably be obtained, which would quite upset the first impressions as to the source of defect.

As has already been shown the first drain on the power may be abnormally large, or, as is more frequently the case, the propeller may be of unsuitable proportions; and it is here where so much trouble is experienced, especially in ships which depart somewhat from the ordinary type.

A series of trials, described in the *Transactions of Institute of Naval Architecture*, were made with a Dutch gunboat some years ago, having different sets of propellers fitted on different occasions. One was 9 ft. diameter by 13 ft. pitch by 30 square ft. area. The other had similar dimensions but half the area.

On Fig. 5 will be seen the horse-power curves as derived over measured mile runs. For medium speeds the two-bladed propeller is the more economical, but as the top speeds are reached the four-bladed propeller gains in efficiency, and becomes the more economical of the two.

The efficiency of the two-bladed propeller at the highest speed is ·655, whilst that of the four-bladed one is ·69.

Great care must be exercised so that the propeller has neither too much nor too little area, as both entail great waste of power.

It is impossible to fix an area ratio which will be suitable under all the varying conditions. The following are a few typical examples for different classes of ships:—

Bancroft ·32,
U.S. Battleship *Illinois* ·332,
Kaiser Wilhelm der Grosse ·39.

Besides the advantages to be gained as regards the knowledge of efficiency of engines built, such analyses provide us with actual wake values and hull efficiency co-efficients which are of great utility in estimating the power and dimensions of propellers for new ships.

Reverting to Fig. 2, the curve of thrust horse-power, that is the power actually utilised by the propeller in overcoming all external resistances, would become the E.H.P. curve, assuming hull efficiency was unity. From this analysis we are able, however, to take into consideration two elements which would otherwise perforce be omitted. The ordinates between T.H.P. and E.H.P. show hull efficiency defect from unity.

Of course an estimate neglecting these items would be on the safe side, but having these values we are enabled to make a closer estimate, thereby saving unnecessary power being put into the ship, which means a saving in cost.

With the increase of revolutions a new source of loss has come to light in some of the fast-running engines of the present day, especially in vessels of the torpedo-boat destroyer class, having speeds of 30 knots and upwards, with engines running from 300 to 400 revolutions per minute.

As the propeller is turning, the water on the rear side must close round it in order that the full efficiency may be maintained.

With high speeds of revolutions, it has been found from progressive trials that with certain propellers speeds have been reached much in excess of the capability of the water to close behind, with the result that air blobs begin to be apparent at the tips, causing a loss in thrust.

The first cause for such a phenomenon is insufficiency of head of water over the blade tips when nearest the surface. The peripheral speed being greater at the circumference, these blobs are formed at the blade tips when nearest the surface, spreading over the whole area as the speed increases. So that if a sufficiently high speed be reached, it is quite possible for the blades to be working in a partial vacuum, merely scraping particles of water from the surrounding aqueous wall, and projecting it aft. This feature is termed cavitation.

Independent investigations have been carried on quite recently by Messrs. S. Barnaby and C. Parsons.

Mr. Barnaby experienced what was at first sight an unaccountable loss of efficiency of the propellers of H.M.S. *Daring*, torpedo boat destroyer. On investigating the subject, he found that cavitation began to set in, with the result that the propeller efficiency was, instead of increasing, rapidly diminishing. This factor depends upon thrust per square inch of projected area and speed. Propellers of greater area were fitted, of such an amount that cavitation did not appear within the upper limit of speed.

There is, of course, a speed for every propeller at which cavitation will begin to make itself apparent; but this limit is not usually reached with propellers of ordinary forms and working under normal conditions.

In his investigations he found that for an immersion of blade tips of 11 ins., an average thrust of 11¼ lbs. per sq. in. of projected blade area was the limit which could be safely adopted.

Mr. Charles Parsons, who was about the same time pursuing independent investigations in connection with the *Turbinia*, arrived at the same conclusions.

In this boat, which is of very light draught, he was compelled to adopt an increased number of propellers to attain the necessary projected blade area. He has three shafts in this boat, and on each shaft, situated at convenient intervals, he has placed three propellers.

According to Mr. Sidney Barnaby, the thrust per square inch may be increased ⅜ lb. for every additional foot of immersion.

Many objections may be urged against giving trials such a complete analysis as has been described, owing to expense and time involved in obtaining the necessary trial data, the long and involved calculations associated therewith and the elements of uncertainty which creep into such results. With regard to the first objection, the writer does not advocate the absolute necessity of analysing every ship and engine built, though this is very desirable, but would urge the importance of having, at any rate, one of every type so tried at intervals. The expense entailed would be more than counterbalanced by the valuable data brought to hand, and the powering of ships would become a scientific problem capable of accurate solution instead of the vague and uncertain method which is now, unfortunately, so frequently adopted in very many instances.

The second objection is simply one which is expressed by many against scientific investigation of any kind, and often serves as a cloak wherewith to cover ignorance.

In conclusion, we may choose one of two distinct types of engines to perform the work to be done. First, the engine may be a quick-running one, entailing a smaller engine with a reduced effective cylinder area, but performing the same amount of work owing to the increased number of revolutions.

The losses due to frictional resistances of engine and propeller are about the same in both cases. In the first we have a large amount of frictional surface with a comparatively low number of revolutions, whilst a quick-running engine has a less amount of area in friction; but against this must be set the increased number of revolutions requisite to perform the same amount of work.

With regard to the propeller the efficiency is just about the same in each case; the large propeller impels a greater race astern with a smaller amount of slip than the smaller propeller, which impels a smaller race, but with an increase of slip.

The useful work done is about identical with that of the large propeller.

The same argument applies to twin *versus* single screws as regards engine efficiency; the propeller efficiencies are here again practically the same, though the conditions under which they work are somewhat different. Each propeller, instead of working right in the wake, has only the side nearest the ship in it, the portion furthest away from the ship works in comparatively still water. This apparent loss is, however, nullified by the loss in thrust deduction, as the water does not receive the same amount of acceleration astern in way of the side as with single screws, so that the useful work is about the same in both cases.

As regards direction of turning, inwards *versus* outwards, one has little advantage over the other. It is convenient to have the starting platform near the centre of the ship, rather than at the sides, in order that the engineer in charge may have greater control over the engines. A drawback to inward turning propellers is that any floating wreckage in the vicinity may be drawn inwards between the propeller and the ship's side, and cause damage to one or the other.

Mr. R. E. Froude conducted some very exhaustive trials for the Admiralty, with the result that he found that the advantage lay with inward turning propellers, but to such a small extent as to be almost negligible.

A. Beaumont Donaldson

Our Scales for Weighing.

By ALLAN GRANGER.

THE scale for weighing is a time-honoured arbiter. As truck-economy has receded into the past, it has played an increasingly large part in commerce, and all along the line it has been the constant handmaiden of science. Nowadays it is the indispensable pendulum of weight transactions, universally and constantly operating in the cause of justice, of which virtue the even-armed balance is a happy and widely recognised symbol. There is a remarkable dearth of literature regarding weighing instruments. This, perhaps, is not surprising when it is remembered that for century after century they underwent little alteration in form and none in principle. On the other hand, so much has been written about weights and measures that a study of metrology is apt to be bewildering.

Equal-Armed Balance.

It may be asserted with confidence that the equal-armed balance is the oldest form of scale. There is evidence to prove that it was in use among the Egyptians, and as the Hebrews are known to have copied the Egyptians in the arts and manufactures, there is little or no doubt that the "balance," to which recurring reference is made in the Bible, was of the equal-armed type. Moreover, numerous as are the theoretical possibilities in the construction of scales, the practical requirements of manufacture greatly reduce the number of possibilities, and of these the simplest and most direct is a plane body with turning motion. Not only is the equal-armed balance the oldest, it is also the most efficient of the various forms of weighing instruments. With scales, as with many other things, the degree of perfection attainable is directly proportional to the simplicity of construction. Although the balance of Mosaic days and that of the present time differ so little in form, naturally there is a vast difference in details. Friction is the great obstacle to the perfecting of the scale beam. To

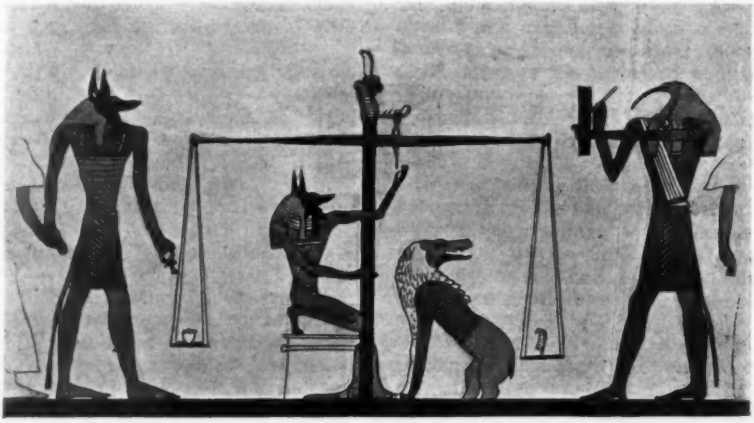


FIG. 1.—ANCIENT EGYPTIAN BALANCE, FROM A PAPYRUS OF 1350 B.C.

overcome this the manner of designing and constructing the working parts, viz., the knife-edges and bearings, is of the first importance. It is here that by the application of scientific methods the perfection of the balance has been brought to a degree that can hardly be imagined. In ordinary commercial scales, great delicacy is neither requisite nor desirable. The rough usage to which they are subjected would very quickly destroy any extreme niceness in the knife-edges and bearings. A trade scale which, when loaded, will turn with a $\frac{1}{20000}$ part of its maximum capacity is sufficiently sensitive for most purposes. What is wanted is to combine sensibility and durability as advantageously as possible, and this result can only be secured in a well-constructed beam of good material.

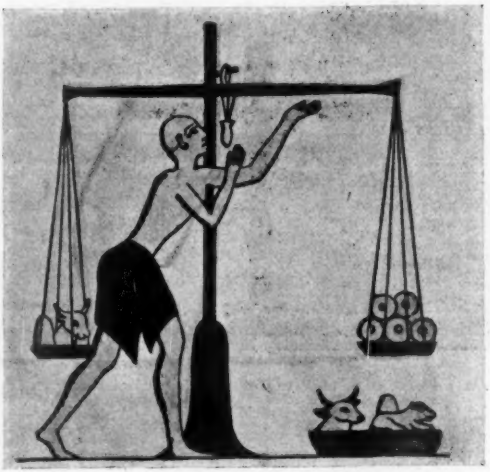


FIG. 2.—BALANCE DEPICTED UPON AN ANCIENT EGYPTIAN TOMBSTONE.

In the British Museum there is an Egyptian papyrus, 1350 B.C. (Fig. 1), on which is portrayed a balance. The scene set forth is that of the Judgment Hall, where, before Osiris, the actions wrought by mortals when in the flesh are being weighed. As the good or bad predominated, the final destiny of the soul was determined. Does this practice suggest a possible explanation of the custom, at one time general enough, and still existent in the Borough of High Wycombe, of periodically weighing the chief magistrate, or ruler of a district? The illustration shown in Fig. 2 was discovered by Lepsius upon an Egyptian tombstone. The person in attendance appears to be weighing rings of gold or silver with weights in the form of a bull's head. The balance seen in Fig. 3 is more modern. Two years ago it came under the eye of an unromantic inspector of weights and measures, and as it was unjust and unstamped, the luckless owner, a farmer, was cited to appear before the bench. He urged that the balance, having served his father, his grandfather, and his great-grandfather, was good enough for him; but Acts of Parliament have no regard for the poetry of life, and he was mulcted in a small fine and had to forfeit the heirloom into the bargain. The centre pivot is a nail, and the strings which support the pans are simply passed through holes in the beam. A balance of this description would, under certain fair conditions, turn to a $\frac{1}{4}$-oz. when loaded with 1 lb. on either side. This shows how easily a rough-and-ready even-armed balance can be put together. Commercial beam scales, which are most generally in use, are too well known to need illustration, as are also the highly sensitive balances which are constructed to carry one gramme in each pan, and turn with 0·005 milligramme, that is, one two hundred-thousandth part of the load.

The Steelyard.

The steelyard is simply an unequal-armed balance. It is almost universally known as the "Roman" balance from the fact that its introduction is generally accredited to the Romans. That this is so is by no means certain. The small Chinese steelyard (Fig. 4) is largely used throughout the Celestial Empire. It has been known there for centuries, and some

FIG. 3.—BALANCE OF MORE RECENT DATE, FOR THE USE OF WHICH A FARMER WAS FINED AND THE BALANCE CONFISCATED.

indeed ascribe a Chinese origin to this type of balance. The weighing appliances shown in Fig. 5 were unearthed at Pompeii, and are still preserved in Italy. A few years ago they were brought together for the purpose of being photographed, and the illustration is reproduced by permission of Messrs. W. and T. Avery, Ltd. It will be observed that in this collection the unequal-armed balance largely predominates. This class of scale possesses two obvious advantages, it is portable, and it dispenses with the need of dead weights; but it cannot, even in a commercial sense, be called an instrument of precision.

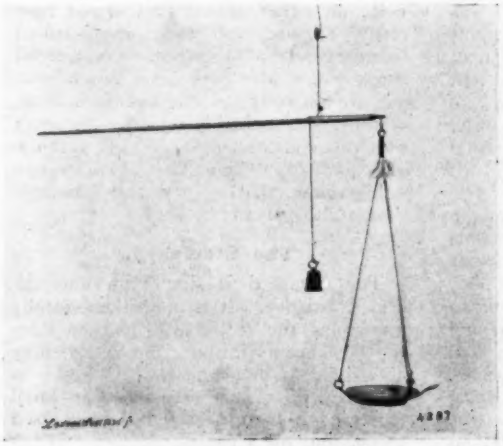


FIG. 4.—SMALL CHINESE STEELYARD.

Counter Machines.

Scales, the pans of which are above the beam, and therefore perfectly free and open for use, obviously afford greater convenience and accommodation than scales with hanging pans. But if, with a single beam, the pans are placed above and secured thereto by means of one pivot or axis only, the equilibrium would be unstable, and the effect or force of the load would vary according to its position on the pan. In the even-armed balance and steelyard where the pans are freely hung, the load, by the force of gravity, acts vertically downwards through the point of suspension, irrespective of its position on the pan. In the "upper-pan" balance it is otherwise, and the conditions of equilibrium, sensibility, and stability are altogether different. The construction of a balance with the pans above the beam was for a long time considered impossible. In 1670, Professor Roberval, a French mathematician, invented a balance, Fig. 6, which may be described as a jointed rectangle, with rods or arms projecting from the upright sides. The striking peculiarity of this balance is, that when equal weights are hung at unequal distances from the centre pivot or axis equilibrium is still maintained. The paradox that it illustrates caused the contrivance to be considered as a mechanical wonder, and it was not supposed to present any useful application. About the beginning of the nineteenth century, however, the idea was adapted to practical purposes, and what is still known as the Roberval

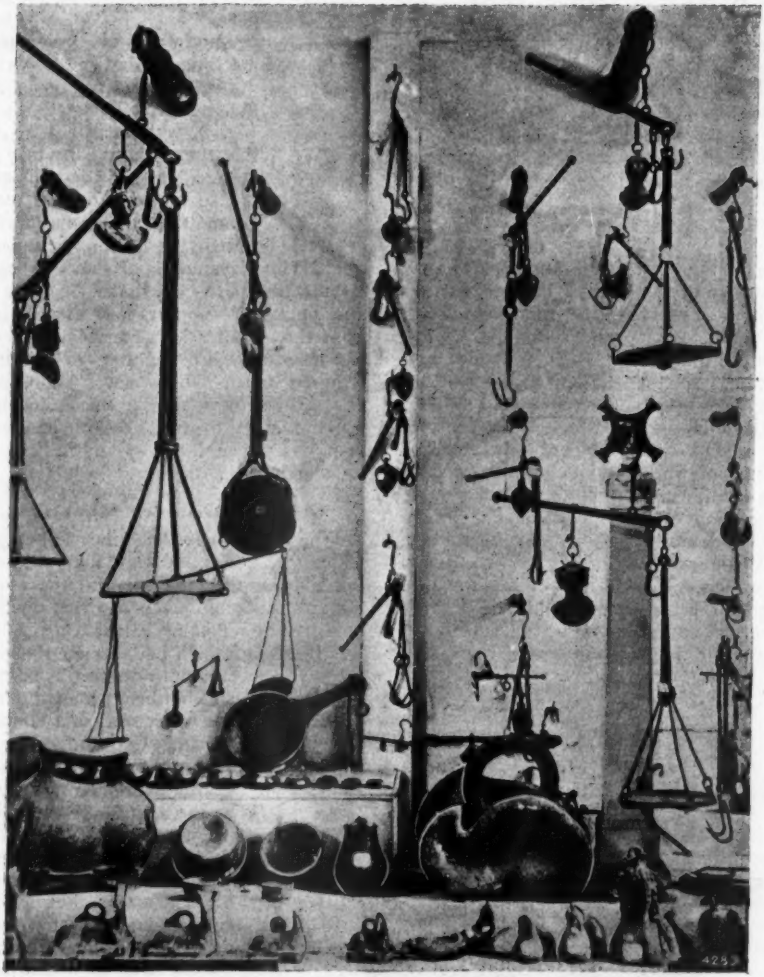


FIG. 5.—WEIGHING APPLIANCES UNEARTHED AT POMPEII AND STILL PRESERVED.

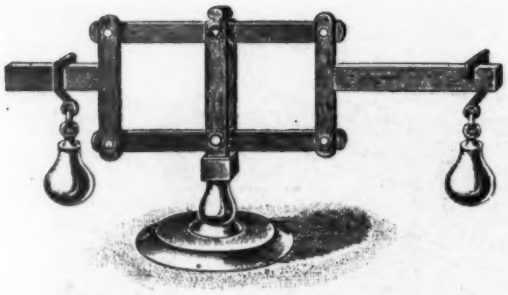


FIG. 6.—THE ORIGINAL ROBERVAL BALANCE.

balance, Fig. 7, was the outcome. From the design of the original balance, Fig. 6, it will be observed that whatever shape the parallelogram may assume, the projecting arms keep parallel to their first position. As the amount of mechanical work done by any force is proportional to the distance through which it moves, the two weights therefore perform the same amount of work, and consequently produce equilibrium. This affords a simple explanation of the phenomenon, which may be demonstrated mathematically by what is known in Mechanics as the theory of couples. Hence it is that in scales founded on this principle the weight of an object is not affected by its accidental position on the pan—an essential property of all weighing instruments. In most machines of this class the principal beam is doubled, as such an arrangement affords a more rigid support for the pans.

Another kind of counter machine is what is known as the "Beranger" balance. An illustration of it is shown in Fig. 8, without the case, so that the working parts may be seen. The subsidiary beams are so coupled to the main beam that the pans always remain in a horizontal position. The advantages of this appliance are that the pans may have as many as four points of support, and their height from the counter is materially reduced. But the increased number of bearings required means additional friction, proportionately increasing as the knife-edges become dulled by wear. Joseph Beranger, of Lyons, patented this system in England on March 19th, 1849.

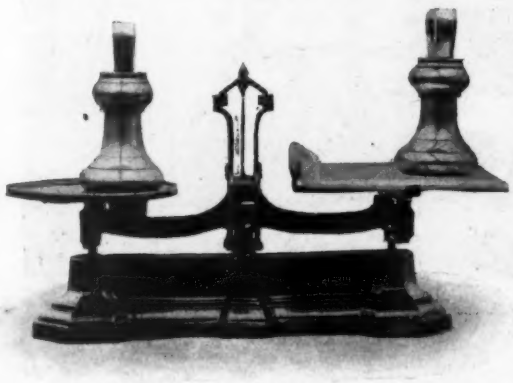


FIG. 7.—THE ROBERVAL BALANCE.

Compound-Lever Machines.

When one considers the large part which the ordinary and familiar compound-lever machines play in the manufactures and commerce of every civilised country, the reflection naturally arises how was their place filled before such machines were introduced. There may still be seen, projecting from the upper story of a house in Soham, Cambridgeshire, a long iron arm, which passers-by not unfrequently take to be the remains of an ancient gallows. Not so; this relic did not in former days serve justice by ridding the world of malefactors, but by preventing malefactions in the matter of weight. The illustration (Fig. 9) will give an idea of the *modus operandi*. The beam and house are shown as they actually exist, the accessories have been worked in. The machine is nothing but a large steel-

yard. The loaded cart was attached to chains, which were suspended from the outer end of the beam; the person then added weights to the other end until the vehicle was hoisted from the ground. Good enough results were so obtained, but the method was slow and cumbrous. This procedure is in marked contrast to the ease and readiness with which the weight of the heaviest loads is recorded by the modern weighbridge or compound-lever weighing machine. It is a simple and ingenious contrivance, consisting in the main of triangular levers coupled together after the manner seen in Fig. 10. For its conception and production the world is indebted to John Wyatt, one of the group of brilliant inventors who adorned the eighteenth century. His claims to memory and honour are set forth by Dr. Smiles in his book "The Hugenots," and likewise in a brochure entitled "John Wyatt, Master Carpenter and Inventor," by Mr. Henry Pooley, of Liverpool. The first cotton-yarn spun by machinery was produced by Wyatt, and a specimen of this is exhibited in the Birmingham Museum and Art Gallery. To his inventive genius the ball-bearing owes it origin. Could he have foreseen the immense application of this idea at the present day, its vast potentialities of wealth would probably have filled him with chagrin, for it was while suffering imprisonment for debt that he devised a readier means of weighing loaded carts than then existed. One of Wyatt's first machines was laid down in Birmingham prior to 1774. Until within a few years ago, there was in use near Lichfield one of the original weighbridges. A model was made from this, and for the picture of it given in Fig. 11 I am indebted to Mr. Laurence Jacob, of Messrs. H. Pooley & Son, Limited. The weight of the load on the platform was ascertained by placing proportional weights upon a small circular plate fixed at the end of the projecting arm, which is a continuation of one of the levers. Wyatt declared that his machine would weigh a load of coal or a pound of butter with equal facility, and with nearly equal accuracy. During a large part of his life he worked at the famous Bolton Foundry, Soho. It is a coincidence that the place has recently passed into the

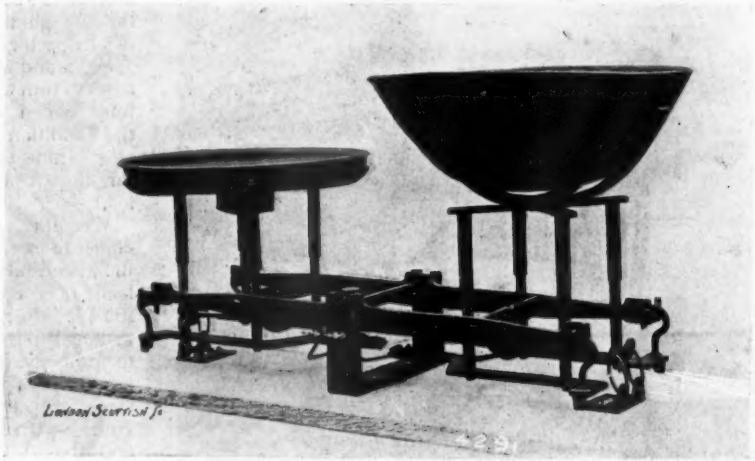


FIG. 8.—THE BERANGER BALANCE.

hands of Messrs. W. & T. Avery, Limited, and is now almost exclusively devoted to the manufacture of weighing apparatus. The addition to Wyatt's machine of an upright pillar to carry a weight-recording steelyard was a great step in advance, for

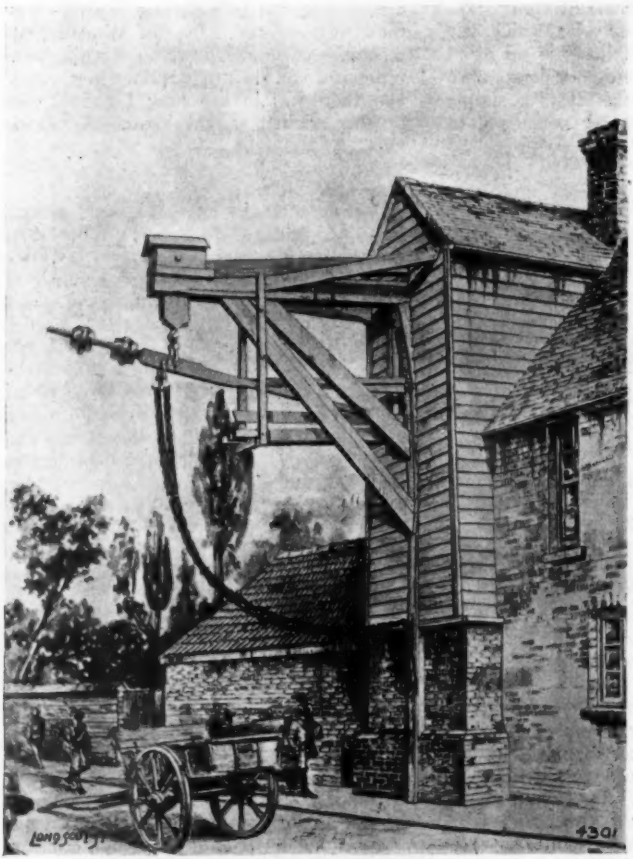


FIG. 9.—OLD CART-WEIGHING MACHINE.

which improvement Messrs. Fairbanks, of America, took out a patent in 1831. This modification opened up a new era in the construction of weighing machines. The English patent was secured by Messrs. Henry Pooley & Son, and the first machine of the kind was placed upon the Liverpool and Manchester Railway in 1835. In the smaller sizes the compound-lever scale is known as the familiar platform machine. The degree of sensibility to which the weighbridge has attained may be judged from the fact that a machine of 100 tons capacity is required by the Board of Trade Regulations issued for the guidance of Inspectors of Weights and Measures to turn when fully loaded with the addition of the nine-thousandth part of the load.

Weighing machines to ascertain the wheel and axle load of locomotives, thereby making it possible to properly regulate the springs of same, are of two kinds—portable and fixed. The former are very convenient, as they may be placed between the rails and can be used without foundation work wherever there is a level length of track. As many machines are required as there are wheels to the locomotive. In the fixed machine there are six, eight, or more separate lengths of weighing rail, each portion being a complete machine in itself, and registering its operations on its own steelyard.

The pillars fixed at the side each supports two steelyards, which are connected with the parallel lengths of rail in front of it. The most recent machines of this description are provided with automatic indicators in place of steelyards, so that the weight upon each wheel of the locomotive is instantaneously indicated. The machine shown in Fig. 12 is in use at Crewe Station.

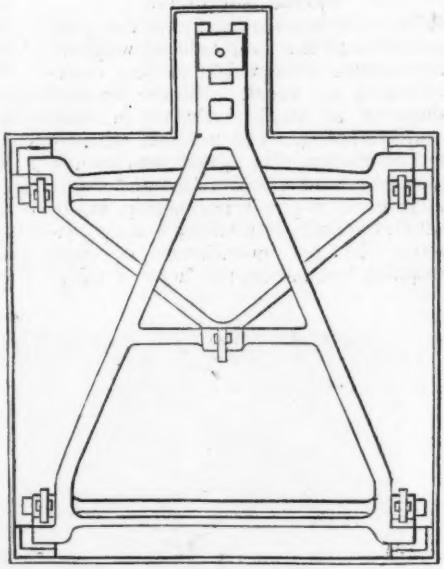


FIG. 10.—DETAILS OF COMPOUND-LEVER WEIGHING MACHINE.

Crane Machines.

As the name suggests they are used in connection with cranes and serve a very useful purpose, as by them the weight of a body can be ascertained at the same time that it is being hoisted. They are of two kinds—one consists of a number of short levers enclosed in a strong case of small dimensions and is inserted in the loading chains; in the other, the whole crane is so arranged that it may be considered as an elevated weighbridge, balanced to carry the necessary accessories and thus enabling the weight of the load hung on to be arrived at directly. The former is to be preferred. It is more sensitive and less liable to get out of order. There may be two, three, four, or more levers, these being multiplied according to the capacity of the machine. The best-known form is that of Denison's, of Leeds, and it has undergone little alteration in design since it was patented by Mr. H. T. Denison, in 1860. The sizes of these machines range from 10 cwt. to 150 tons. (Fig. 13.)

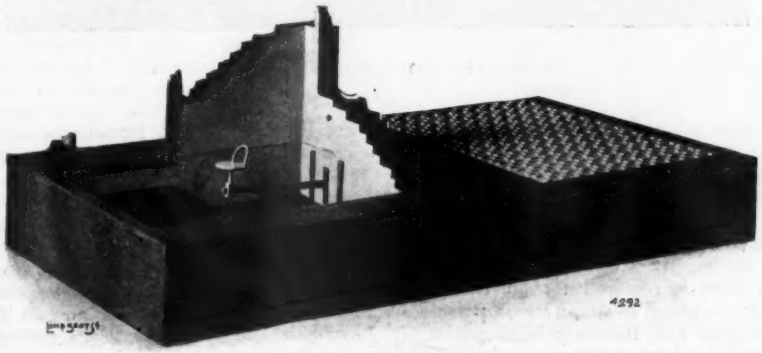


FIG. 11.—MODEL OF WYATT'S CART-WEIGHING MACHINE.

Spring Balances.

This class of scale constitutes the great exception to the lever order of weighing instruments. The weight is here determined by the alteration of the form or shape of an elastic body, or, in other words, a spring. The principle underlying the construction is, that between the force and the alteration of form and shape, there exists a certain relationship which, within the limits of elasticity, is fairly constant. In the manufacture of such weighing instruments, the factor of prime importance is the shape of the spring. A steel bar would, in a measure, serve the purpose, and springs of an elliptical shape have been used to some extent, but their use in this connection has been discontinued, as balances so constructed were not sufficiently sensitive. It is obvious that what is required for practical purposes is a shape of spring which possesses a uniform and relatively large degree of extension. The screw spring, or, as it is generally called, the spiral spring, best answers these requirements. The manufacture of balances embodying this device was commenced about the year 1760, at Bilston, by Mr. Richard Salter. At his death in 1815 the business was transferred to West Bromwich. The first kind made was known as the "Pocket Steelyard," which consisted of a screw spring enclosed in a round iron tube which bore the graduation marks. In the early days all the springs were made from old files, which were drawn down and rounded to gauge on an anvil. The wire thus made was then coiled, and formed the spring. The spring balance having a flat brass plate, on the side of which the weights are marked, and which is traversed by an indicating finger, was first made about 1829, and the "Family Balance," where the goods pan is above the spring, in 1866 (Fig. 14). As spring-weighing instruments are quick in action, and as they avoid the use of weights, they are suitable appliances where dispatch in weighing is of the first importance. Spring balances

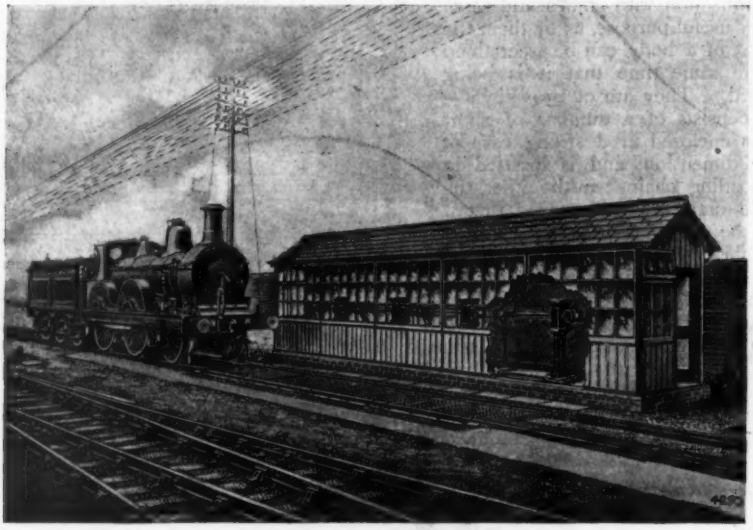


FIG. 12.—LOCOMOTIVE WEIGHING MACHINE.

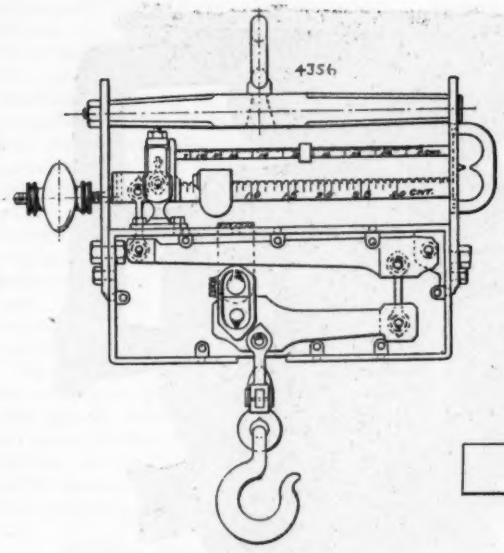


FIG. 13.—INTERIOR VIEW OF A CRANE MACHINE.

admitted for use in trade the best are based upon the principle of the even-armed balance. Their design is therefore of the simplest, and it is only the mechanism which is necessary for the serving and shutting-off operations that make them appear complicated. As in the simple beam scale, the receiving receptacle is suspended from the one end and the counterpoise from the other. At the instant that the weight of the material poured into the pan, or other vessel, equals the weight of the counterpoise, the beam begins to move. This automatic movement are often used in combination with compound-lever weighing machines.

Automatic Scales.

The constant repetition of certain processes of weighing, such as the sorting of coins, or the blanks for same, the making up of packages, and the checking of grain from ships, has led to many endeavours to devise means of accomplishing them in an automatic manner.

Automatic sorting scales have been successfully used in mints and banks for about the last sixty years. The construction of these machines is very complicated, and they constitute a special class of scale which does not fall within the scope of this article. Of the various automatic weighing machines which are

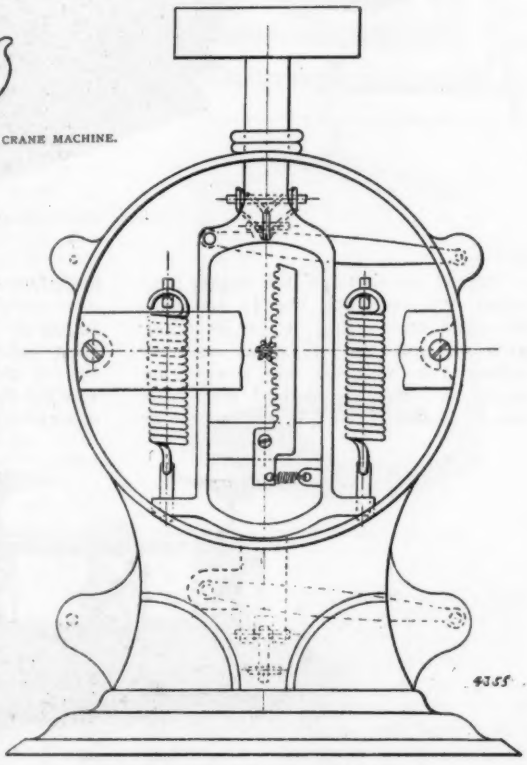


FIG. 14.—INTERIOR VIEW OF SPRING BALANCE.

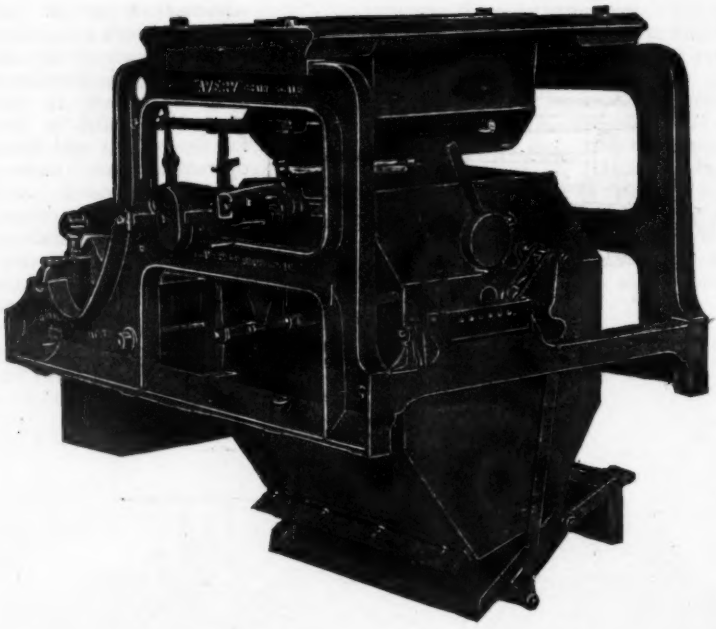


FIG. 15.—AUTOMATIC GRAIN WEIGHER.

is utilised to shut off the supply; to empty the receiving vessel; to close the same and return it to its filling position; and also in some cases to register the weighing on a counting apparatus. By this method the errors that may arise from the clumsiness or forgetfulness of the operator are avoided. The chief consideration, however, is accuracy. With automatic scales the great difficulty in this respect has been, that at the moment the correct weight was on the scale and the supply consequently shut off, there was a stream of

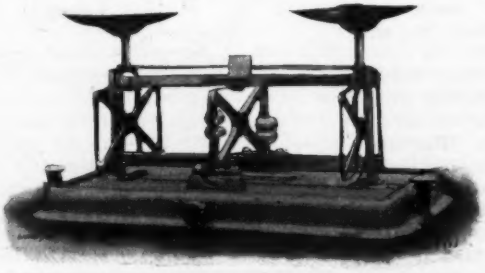


FIG. 16.—TORSION BALANCE.

unweighed material in the air which flowed into the receiving vessel. This defect has been overcome. The flow of the substance into the receiver is so graduated by means of automatic shut-off arrangements that it tapers down to a fine stream towards the end of each operation; and the beam, by an adjustable attachment is given a slight start which shuts off the supply in such a manner that the quantity of material in suspension at the given moment serves to make good the required weight of the load. Being an equal-armed balance the accuracy of the result can be proved at sight after each weighing (Fig. 15).

Mention may perhaps be made here of the ubiquitous penny-in-the-slot machine. Although in point of sensibility it might not meet the requirements of official verification, yet for the purpose to which it is put it answers well, and is undoubtedly very ingenious.

Recent Developments.

Within the last few years computing balances of various makes have been introduced into this country from the other side of the Atlantic, and also, though by no means so recently, the Torsion Balance. In the Torsion Balance (Fig. 16) the knife-edge centres and their bearings, common to all our lever scales, find no place. In their stead are pieces of wire stretched to a high degree of tension. The advantages claimed for this system are durability and less liability to derangement. As so far it has only been adopted to a small extent here, it is difficult to gauge its merits from a practical point of view.

Computing balances mark a distinct advance in this particular branch of mechanics. They ascertain the weight of the goods placed upon them, and in addition compute their value, *i.e.*, they give not only a weight value in avoirdupois pounds and ounces, but also a money value in pounds, shillings, and pence. The specimen shown in Fig. 17 is a spring balance. Its weighing capacity is 20 lbs., and it computes values of from 2½d. to 1s. 6d. per pound. The weight of the goods placed upon the pans is indicated upon a vertical slide which is graduated in ¼ ozs. Of the two horizontal rows of figures those of the lower row state the price per pound, and, of course, remain fixed. Those above these prices change as the slide indicating the weight moves downwards, and in such a way that they show the value of the goods on the pan at the price per pound which appears

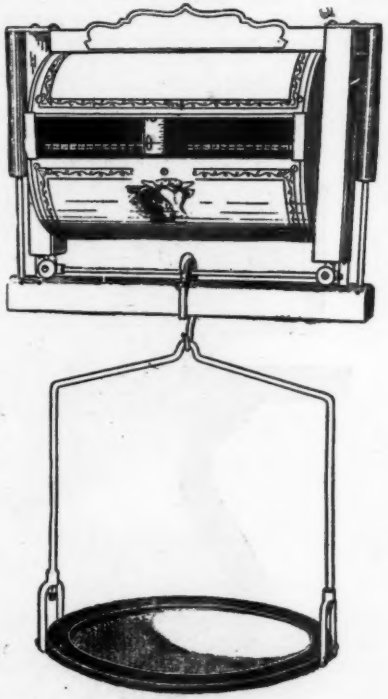


FIG. 17.—COMPUTING SPRING BALANCE.

below them. Air cushions and a thermostat are introduced into the construction of these scales. The object of the former is to reduce vibration and of the latter to prevent variation in the springs in varying temperatures. It cannot be said that these objects are thereby fully attained, and consequently the faults inherent in spring weighing instruments are

not overcome in this particular machine. What is known as the "Stimpson Computing Scale" (Fig. 18) is a lever weighing machine, carrying a chart which serves as a steelyard. This is traversed by a flat sliding poise upon which the prices per pound are marked. The upper border of the frame enclosing the chart is graduated in pounds by ½ ozs. When a weighing has been effected in the usual way, the price per pound of the goods is sought upon the traversing poise, and the figures which appear next to this on the chart give the value at that rate. From an official point of view no objection can be raised to the principle of this appliance, as it is simply the ordinary compound lever machine with a computing arrangement so attached to the steelyard that at one and the same operation both the weight and value of the goods are ascertained. Another form of computing scale, known as the "Ready Reckoner," is illustrated in Fig. 19. Here the indicator upon the lower dial is fixed according to the rate per pound of the

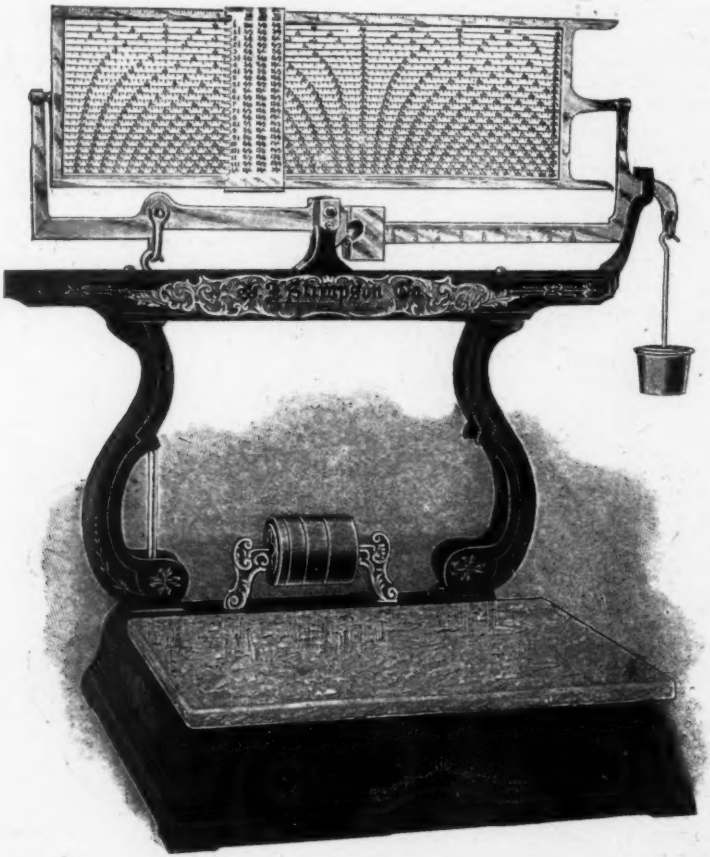


FIG. 18.—THE "STIMPSON" COMPUTING BALANCE.

FIG. 19.—THE "READY RECKONER" SCALE.

article being weighed. The poise is then moved along the steelyard to arrive at the weight. The poise in moving actuates the figures of the upper dial, so that the value of the goods according to the rate fixed upon may be simultaneously read off. The indication of the value is clear, and the arrangement by which the sliding poise performs its computing function is simplicity itself. From the description given it will be evident that the computing power of the machine does not extend beyond the range of the steelyard. Money weight scales have been admitted for use in trade in this country. They are said to be very generally employed in America. It remains to be seen to what extent they will suit the likings and habits of John Bull.

Allan Granger

Laundry Engineering.

By F. J. ROWAN, A.M.Inst.C.E.

(*Continued from page 116.*)

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It has often been suggested that as the removal of dirt from fabrics (cotton or woollen) by soap, soda, or bleaching materials is a chemical process, the mere passage of the liquid containing these substances through the material of which clothes are made should be enough to cleanse them. Attempts have consequently been made from time to time to impart additional velocity to the currents of the water ordinarily produced by boiling in clothes boilers, these attempts being made chiefly by means of some modification of the stand-pipe arrangement used in boiling yarn. This system, however, demands for success an equality of texture in the articles treated which it is impossible to obtain with manufactured articles or wearing apparel, where seams and several thicknesses may be present in the same article or garment. With such material as yarn the case is different, but with clothes the thicker parts need additional treatment, and this destroys the uniformity of the process and introduces the necessity for some equivalent of the action of rubbing by hand. That is to say, a gentle mechanical friction, in addition to the slight friction provided by the passage of the liquid, has been found necessary, and the problem has been to supply this with the least amount of damage to the fabrics treated.

In general design the machinery used in laundries is limited to a few types, which have not changed to an appreciable extent during a number of years. Details have been improved and amplified, but the fundamental ideas remain the same. Some of the earliest forms were introduced in France and some in America, but one of the oldest forms of the washing machine now in general use was introduced as a hand machine in this country forty to fifty years ago.

FIG. 1.—IMPROVED STEAM BOILING COPPERS, SQUARE TYPE.

In the initial stage of washing operations there is sometimes a need of open troughs for soaking or washing. These require no description. They are constructed of pitch pine, with brackets or supports of wood or iron, or in pottery ware or enamelled iron. When not constructed of wood they are most frequently made in earthenware, the principal makers being Adams of York, Craig of Kilmarnock, Doulton of Lambeth, Shanks of Barrhead, and Twyford of London. In modern laundries the old-fashioned cast-iron open boiler, with fire underneath, has given place to vessels of copper or to wooden vats, with perforated steam boiling apparatus. Figs. 1 and 2 show how

boiling coppers are differently arranged by Messrs. Manlove, Alliott & Co., Ltd.; and Fig. 3 illustrates a specimen boiling vat with drainer, as made by the Manchester Laundry Engineering Co.

In its older form the washing machine consisted of a revolving box of irregular octagonal shape. This box was usually made of wood, and was mounted with its gearing on cast-iron standards. The clothes were, with the water and soap solutions, inserted and removed by means of a door, and latterly an india-rubber roller wringer was mounted on the frame at the top. Later forms are almost always constructed in metal, and consist of an inner revolving basket or perforated cylinder which contains the clothes, and an outer stationary cylinder which holds the water, soap solution, and steam when wanted. These machines are driven by belts on pulleys, and have automatic reversing gear, by which the direction of rotation is reversed every few revolutions. Fig. 4 shows a typical machine of this kind for cold water or steam of atmospheric pressure, with the outer case open; and Fig. 5 shows both outer case and inner perforated cylinder open, ready to receive clothes. For working with steam under pressure a stronger construction of the outer cylinder, and especially of the door and steam fittings, is required. This is shown in Fig. 6, which illustrates the pressure washing machine with a water motor attached for driving it, instead of the usual belt pulleys.

The Leicester Laundry Engineering Co have introduced a novelty in the construction of washing machines by arranging the doors at one end, as shown in Fig. 7, instead of in the usual position at the front. The inner cylinder or basket is divided into two compartments by a division across the centre. It is claimed that these modifications in design render the work of loading and unloading easier for the attendants, and enable the superfluous water to be drained from the top half-cylinder before the clothes are removed. Also that articles of different quality may be separately dealt with in the same machine. The joints and doors are certainly less subject to strains from the weight of wet clothes being repeatedly thrown on them, and the belts and gearing are placed at the furthest point of the

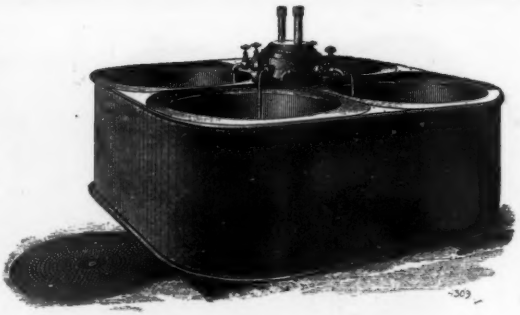


FIG. 2.—IMPROVED STEAM BOILING COPPERS, CIRCULAR TYPE.

FIG. 3.—BOILING VAT AND DRAINER

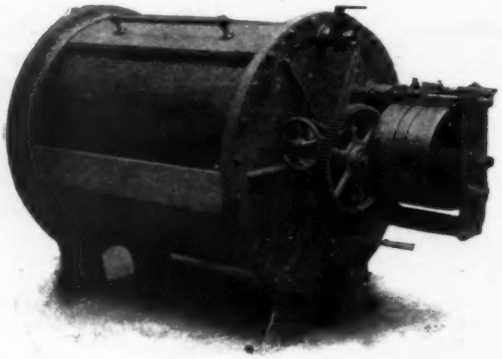


FIG. 4.
IRON PRESSURE WASHING MACHINE,
SHOWING INTERIOR
PERFORATED SHELL.

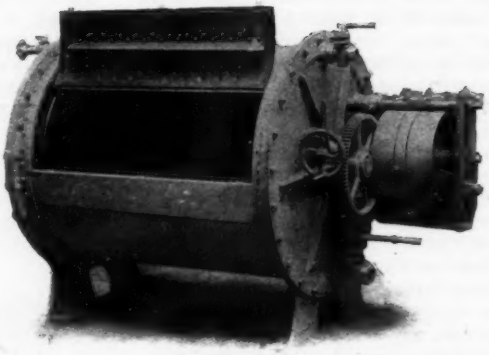
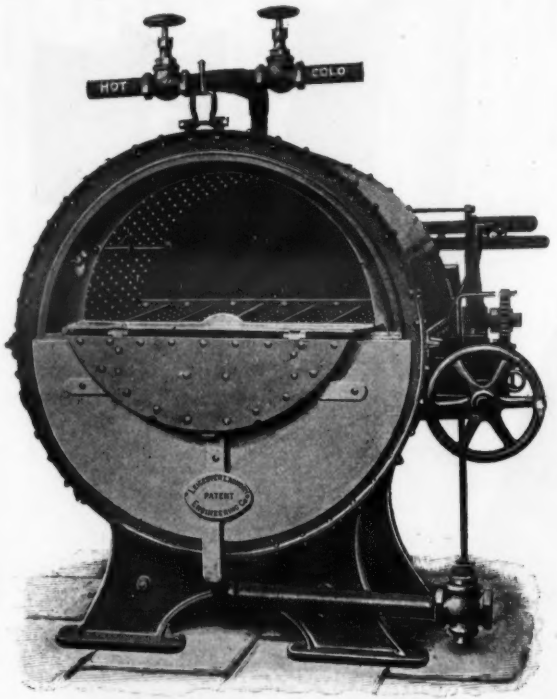
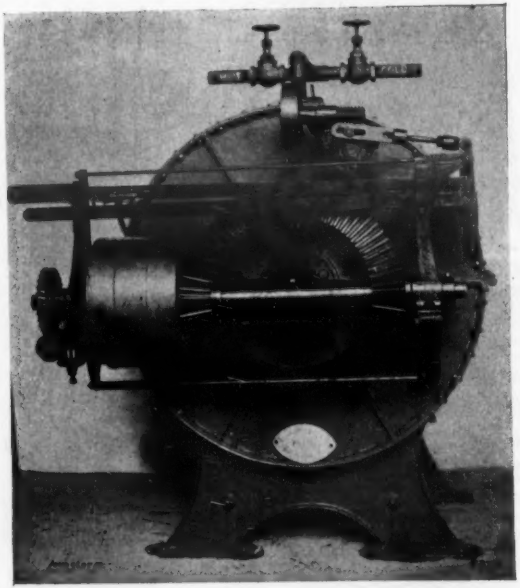


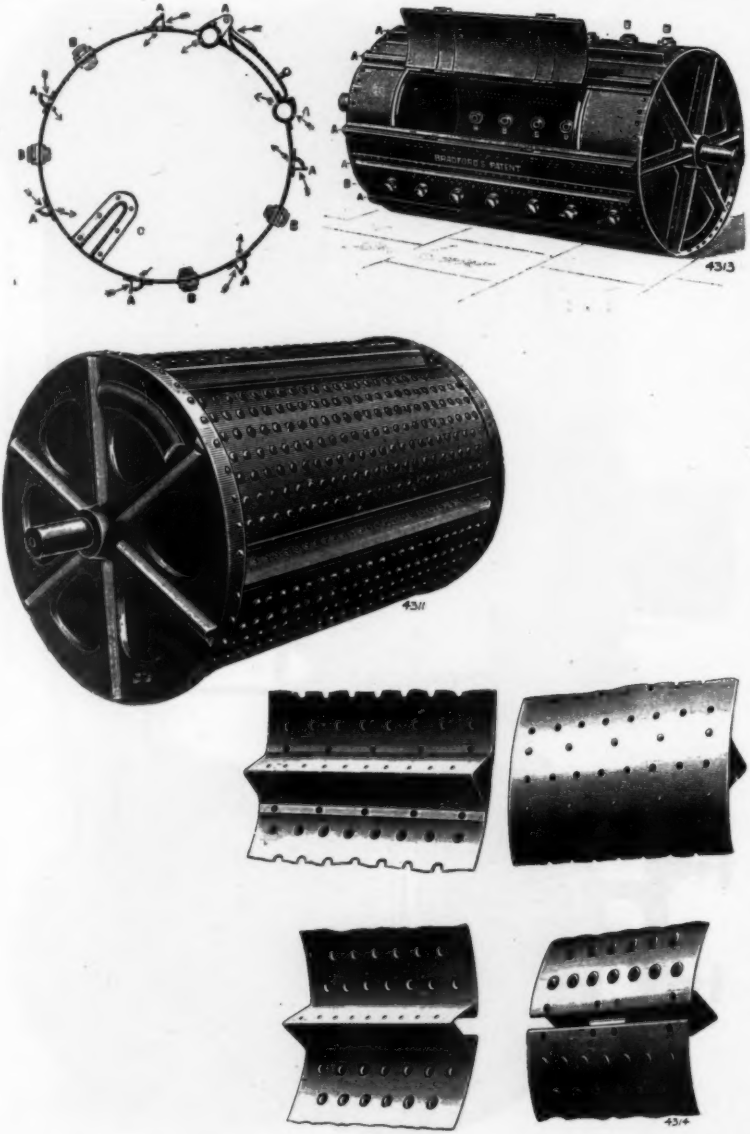
FIG. 5.
WASHING MACHINE,
SHOWING BOTH OUTER CASE AND
INNER CYLINDER OPEN.

FIG. 6.
PRESSURE WASHING MACHINE,
ARRANGED TO BE
DRIVEN BY WATER MOTOR.





FIGS. 7. AND 8.—TYPE OF WASHING MACHINE MADE BY THE LEICESTER LAUNDRY ENGINEERING CO.



FIGS. 9, 10, 11.—METHODS OF CONSTRUCTING THE INNER SHELL OR CYLINDER OF WASHING MACHINES.

machine away from the attendant, so that risk of accident is thus diminished.

Great ingenuity has been displayed in working out and perfecting the details of such machines. Different sizes and forms of clothes lifters had to be tried before the best was arrived at, so that a gentle rubbing movement should be imparted, and the necessity for unravelling the clothes obviated. The frequent reversals of the direction of rotation aid in the attainment of this latter object. Then again the inner cage has to be constructed with the minimum of projections inside, rivet and bolt-heads being done away with, as well as any roughness such as would tend to the destruction of the goods being washed. There is not space in this series of articles to permit of these and other details being dealt with, or the points of difference between the machines of different makers being indicated. Some of these points are dealt with in an interesting paper on "Steam Laundry Machinery" in the Proceedings of the Institution of Mechanical Engineers for April, 1898, and the finely illustrated catalogues of the various makers enable anyone desirous of studying the machines to observe the special features of different plans. To arrive at this result by inspection of machines in laundries would demand much time, as the number of laundries is large. Two varieties of construction of the inner shell or cylinder may be seen in Figs. 9, 10 and 11, the former being that of Messrs. Thos. Bradford & Co., and the latter that of Messrs. D. and J. Tullis.

Figs. 12 and 13 illustrate the system of washing by means of the action of beaters or "dollies" on the clothes. This action, if severe, would of course destroy any but the coarsest of fabrics; but it can be made quite light and gentle, so that it is not surprising to find that it is often preferred for washing lace and knitted fabrics, which are of delicate constitution.

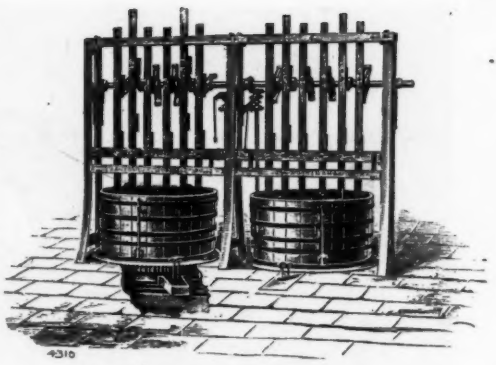


FIG. 12.—THE "DOLLY" WASHER.

Fig. 14 shows a special washing machine for blankets and flannel, designed by Messrs. D. and J. Tullis. These latter

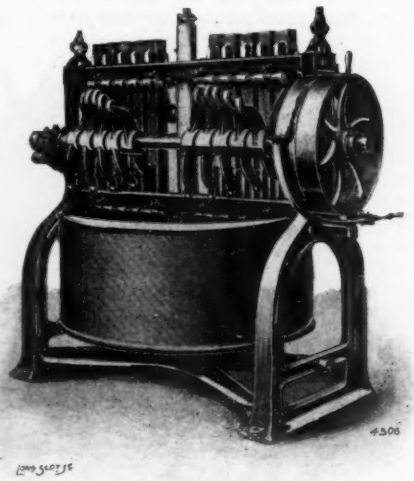


FIG. 13.—THE "MACALPINE" WASHING MACHINE.

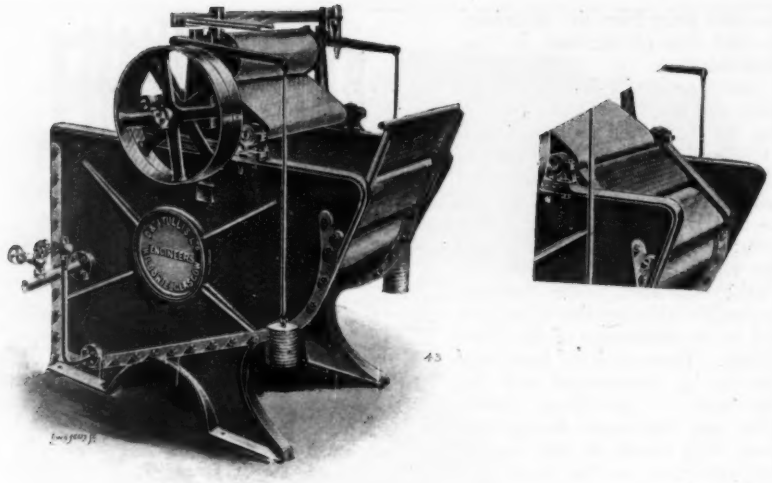


FIG. 14.—BLANKET AND FLANNEL WASHING MACHINE.

machines are open, and are, of course, intended for use with cold water, or with water kept hot by steam injection, and not for boiling or steam pressure.

There is a variety in the methods of using washing machines. The non-pressure or atmospheric pressure machines are sometimes used for rinsing, blueing, and starching, as well as washing, and the pressure machines frequently have boiling and disinfecting added to their rôle as washers. These are, however, details o

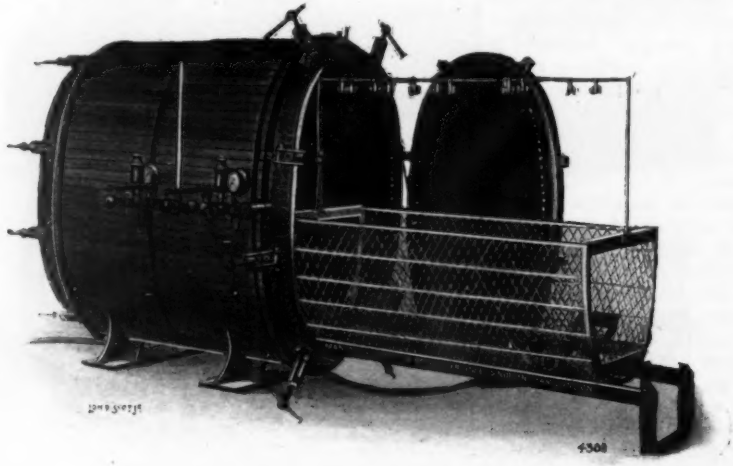


FIG. 15.—WASHINGTON LYON'S PATENT STEAM DISINFECTOR.

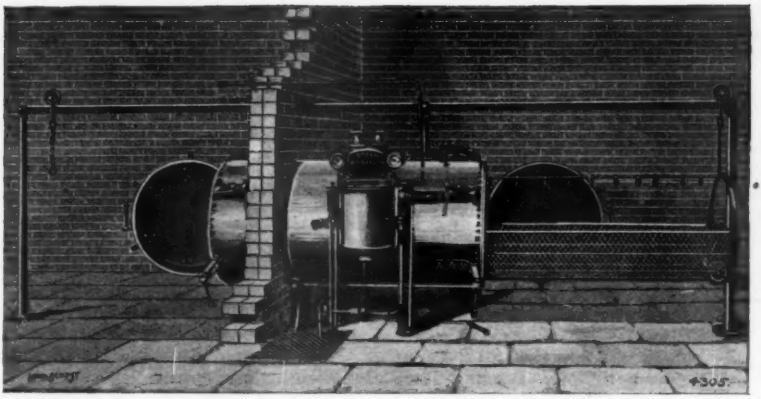


FIG. 16.—MESSRS. ALLIOTT AND PATON'S DISINFECTOR.

laundry practice, except in so far that the design of the washing machine and the material of which it is constructed must necessarily be determined by the purpose for which it is wanted, and it is thus necessary to keep practice in view for sound engineering.

Although pressure washing machines of the revolving cylinder pattern are used for disinfecting clothes, and that action is due to the temperature which can be produced in them, still many sanitary authorities prefer to have a special apparatus for disinfecting alone, as a preliminary to the subsequent washing or cleansing.

The best known of such disinfectors are possibly those of Washington Lyon, of which Fig. 15 gives an illustration, and of Reck. Saturated steam of high pressure is used in them, and the apparatus is steam-jacketed because it is important that the articles being disinfected should not be wetted. The fact, however, that wetting sometimes occurs has led to various improvements being proposed, such as making use of a current of hot air. Air has been found, however, to be inferior to steam for disinfecting purposes, and for the same reason it is desirable to remove the air which is held enclosed in the pores of materials, such as bedding and clothing, which are submitted to the action of steam, in order that the steam should thoroughly permeate them; otherwise the air may be simply compressed in them, causing the disinfecting action to be too much confined to the surface. A preliminary exhaustion of the air seems, therefore, to be demanded, and this is provided for in the more recent disinfector of Alliott & Paton, which is illustrated in Fig. 16. In addition to penetrating the material exposed to it, this preliminary exhaustion of the air also renders the apparatus more effective when a baking action is wanted, the steam being admitted only to the cylinder jacket in that event.

(To be continued.)

Fred. Geo. Rowan

Modern Compound Locomotives.

By CHARLES S. LAKE.

Section I.—ENGLISH AND FRENCH LOCOMOTIVES.

(Webb and De Glehn Systems.)

OF all the debatable questions which surround the subject of locomotive design, that of "Compound *v.* Simple" is perhaps *the* one which is productive of the greatest number of controversial points.

These comprise in themselves technical matters of the most absorbing interest, which can only be adequately dealt with in the course of a lengthy and expert discussion by those who have studied the principles which govern the distribution of steam, involving incidentally the whole subject of its expansive quality and the method of applying the same, in order that the utmost possible advantage may be obtained.

Theoretically speaking, at least, the compound locomotive *should* be a success. This much is generally conceded, even by the most strenuous opponents of the low-pressure cylinder; but if examples were needed to prove that it is not always so, we have only to turn to the somewhat numerous cases where engines—which were originally built as compounds—have, after only a year or so of working, been converted to simples, the process resulting in a decided increase in their efficiency.

In instances such as these, the lack of success is, unquestionably, attributable to some inherent fault in the individual design, and cannot in any way be adduced as proof that the principle of compounding is, in itself, a wrong one.

But even among those engineers who are agreed as to the advantages which are to be gained by the employment of compound locomotives, a remarkable diversity of opinion exists upon many of the most vital points which have to be considered at the outset when a new type of engine is being designed.

The paramount consideration is that of the relative areas which the cylinders should possess, or, in other words, the ratio of the high-pressure to the low-pressure cylinder, for upon the satisfactory solution of this problem the success of the whole design depends.

Although a certain amount of fairly reliable data, bearing upon this important point, is available, still there is no recognized rule for the guidance of the engineer, who has to decide this essential question before it is possible for him to proceed with the further details of the design.

There can be little doubt but that the failure, in the past, of many otherwise admirably proportioned compound locomotives may justly be attributed to the one fact of their having been provided with cylinders which were not so proportioned as to present the necessary facilities for the steam to perform its work in the manner intended; and although the error in calculation may in some cases have been comparatively slight, yet it was sufficient to debar that particular class of engines from being described as satisfactory and to warrant their being rebuilt as non-compounds.

Another important point which has to be determined is that of the *number* of cylinders which are to be employed, and the manner in which they shall be arranged.

Some engineers are in favour of using three, and others four, whilst the practice of constructing two-cylinder compound locomotives is, generally speaking, less

favoured at the present time than was formerly the case.

The four-cylinder engine, on the other hand, is rapidly growing in popularity. It has been found in actual practice that the best results are to be obtained with this type.

The initial cost of building is little or no more than in the case of the three-cylinder variety, and although there is much to be said in support of the latter, a great deal more may be urged on behalf of the quadruple design.

position as those in Mr. Webb's engine, but the high-pressure are located immediately ahead of the leading pair of coupled wheels, the trailing pair in this instance forming the high-pressure drivers.

This arrangement, it will be remembered, is one of the most prominent features in Mr. Webb's three-cylinder compounds, and also in the four-cylinder simple engines which have during recent years been constructed for the London and South-Western Railway from the designs

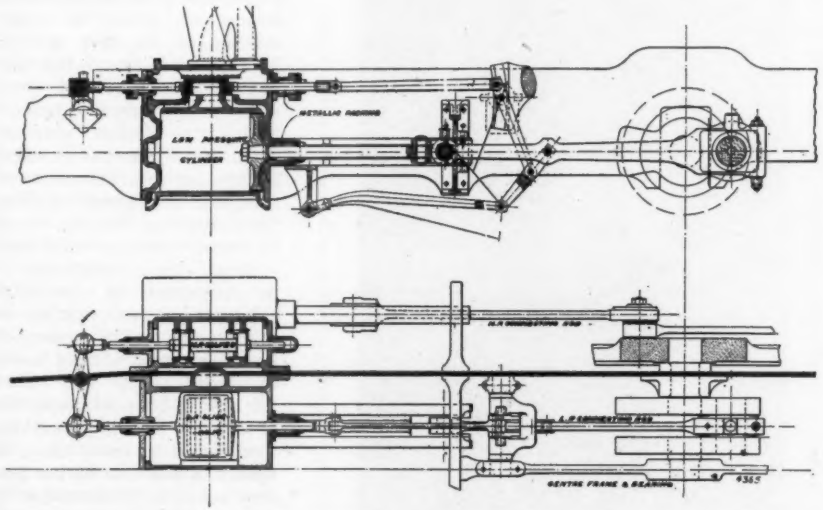


FIG. 1.—7-FT. FOUR-WHEELS COUPLED COMPOUND PASSENGER ENGINE, F. W. WEBB'S SYSTEM: ARRANGEMENT OF HIGH-PRESSURE AND LOW-PRESSURE VALVE GEAR.

The most convenient methods of arranging the four cylinders appear to be those adopted by Mr. Webb on the London and North Western Railway and Mons. de Bosquet on the Northern of France.

In the former case they are placed all in line, the high-pressure being situated outside and the low-pressure between the frames below the smoke-box in the usual way.

In the French locomotives the low-pressure cylinders occupy the same

of Mr. Dugald Drummond, that Company's Locomotive Superintendent.

Both of these methods have their advantages, but for reasons of space the author will not at this juncture attempt to discuss the subject of their individual claims, but will at once proceed to a description of the most recently constructed compound locomotives of the present day. The four most prominent compound "systems" of modern times are those which, by taking the names of their inventors, are known respectively as

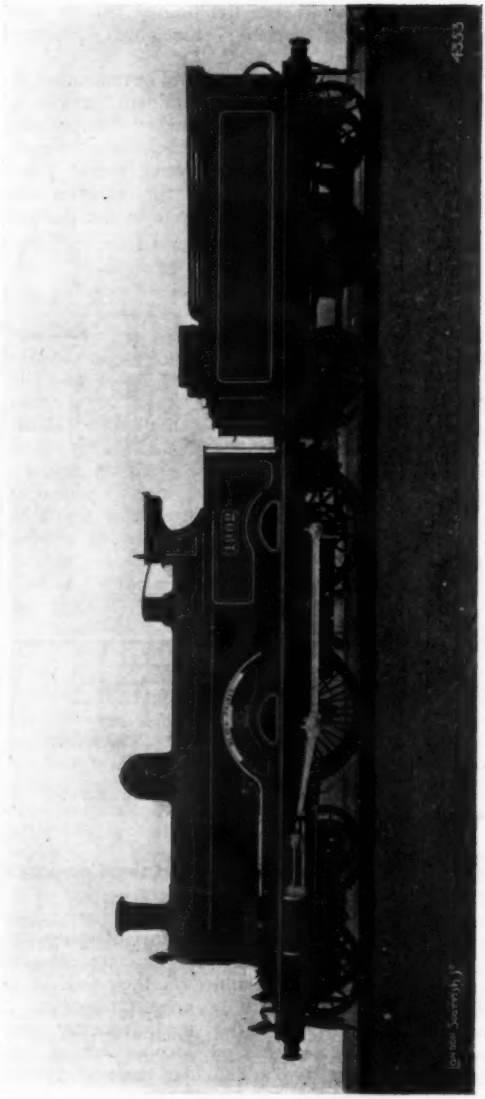


FIG. 2.—L. AND N. W. RAILWAY FOUR-CYLINDER COMPOUND EXPRESS LOCOMOTIVE OF THE EARLIER SERIES. (F. W. WEBB'S SYSTEM.)

the Webb, De Glehn, Göldsdorf and Vauclain.

Large numbers of engines of each denomination have been constructed, and are employed upon the various railways for which they were built in performing work of the most arduous and important description.

Dealing with these in the order in which they are set forth above, we have first to consider the well-known system of Mr. F. W. Webb, whose tenure of office as chief mechanical engineer of the London and North-Western Railway has extended over upwards of thirty-two years,* during the greater part of which period he has devoted a very considerable amount of time and energy in bringing the compound locomotive to its present state of efficiency —a fact which entitles him to be considered as the chief exponent of the principle in this country. The history of his experiments (dating back, as they do, to the year 1882) has already been so frequently chronicled that it would be inadvisable to recapitulate it here, and now that he has discontinued the construction of three-cylinder engines, and is confining his attention exclusively to the four-cylinder types — both passenger and goods — the author's announced intention of exemplifying the locomotives of the

* At the half-yearly meeting of the L. & N. W. shareholders, held on Aug. 13th last, Lord Stalbridge, the chairman of the Company, referred to the statements which were being circulated at that time in the columns of the daily press to the effect that Mr. Webb was about to retire from his position as chief Mechanical Superintendent. His lordship deeply deplored the fact that such reports should have gained currency and, after emphatically asserting that no truth whatever existed in them, expressed the hope that some number of years would elapse before such an announcement would be officially made.

most recent design only will be adhered to, if the engines known as the "Black Prince" class are taken as the first example to be described.

Previous to the introduction of this series all Mr. Webb's engines were of the single leading axle type, with radial axle boxes to the leading wheels. Apart from any question of opinion as to the advantages of the bogie, it would have been a matter of extreme difficulty, if not of impossibility, to carry the leading end of the three-cylinder compounds upon a four-wheeled truck, on account of the presence of the low-pressure cylinder (with its large diameter of 30 ins.) between the frames, in the same position as that occupied by the two low-pressure cylinders in the present instance. In consequence of the substitution of the two cylinders of smaller diameter for the original one, of exceptional size, it has been found possible to provide the new engines with a double radial truck, the centre of which is fitted with Mr. Webb's radial axle box and central controlling spring. This arrangement permits of one-inch side-play, and allows of greater freedom in the movements of the truck when traversing curves than is possible with the ordinary rigid centre-pin type of bogie.

Reference has already been made to the fact that the cylinders are placed in line, with the high-pressure outside and the low-pressure between the frames at right angles with the longitudinal axis of the engine. By this arrangement it is possible for all four sets of motion to be connected up to the one axle, this axle being

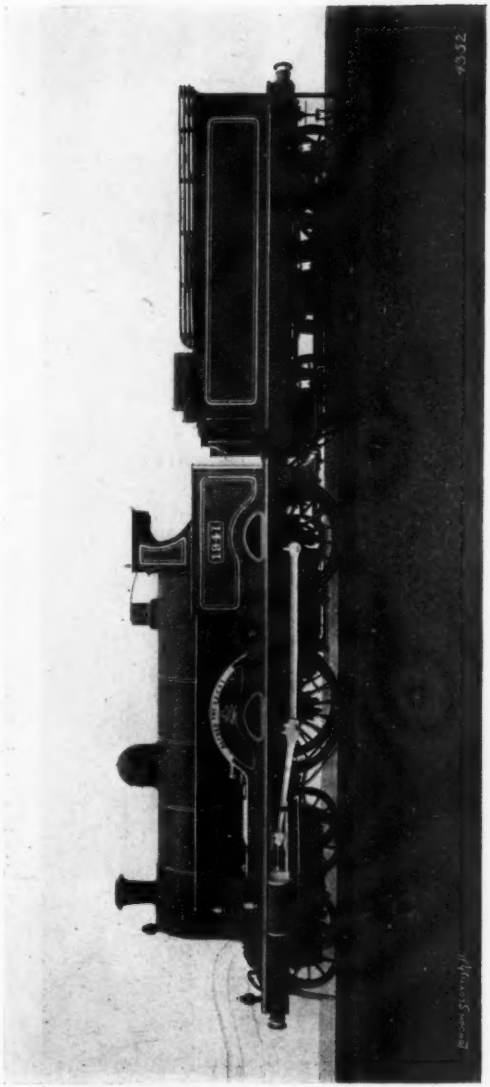


FIG. 3.—L. AND N. W. RAILWAY FOUR-COUPLED COMPOUND EXPRESS LOCOMOTIVE OF THE LATER SERIES. (F. W. WEBB'S SYSTEM.)

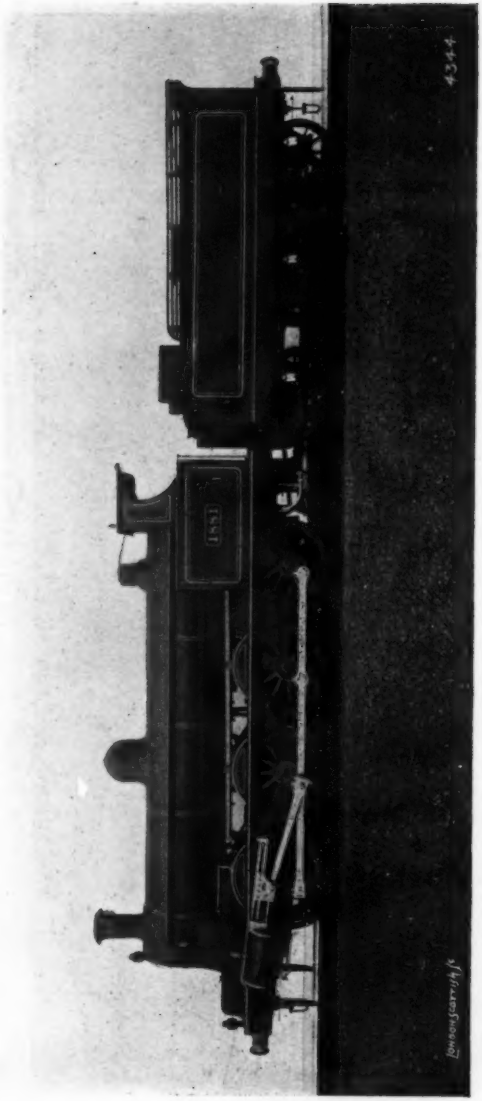


FIG. 4.—4 FT. 3 IN. EIGHT-COUPLED COMPOUND GOODS LOCOMOTIVE. (F. W. WEBB'S SYSTEM.)

coupled to that of the trailing pair of wheels behind the fire-box (Fig. 2).

The high-pressure and the low-pressure cranks on the left-hand side of the engine are placed opposite one another, 180 degs. apart, as in a bicycle. Those on the right-hand side are similarly situated, but in the opposite direction to those on the left-hand—that is to say, one pair of cranks follows the vertical and the other the horizontal centre-line of the wheel, thereby causing the relative angle of the one pair of cranks to the other to be 90 degs., as in an ordinary two-cylinder engine. This arrangement gives a very even turning movement to the crank axle, and renders the use of rim balance-weights unnecessary, all that is required in this direction being fully supplied by the discs 2 ft. 9 ins. in diameter, which are cast round the centres of the coupled wheels.

A distinctive and highly commendable feature of this design is the method which has been adopted for working the slide valves. By means of an ingenious yet simple arrangement, comprised of but very few working parts, only two sets of gear are required for working the four valves.

The motion is Joy's, which is applied to the low-pressure cylinders in the usual manner. The spindle of the low-pressure valve is extended and passes through the front of the steam-chest, and on the end of this spindle a cross-head is fixed, having a loose phosphor-bronze bush which is free to turn within the cross-head. A lever of the first

order, which is pivoted in such a position as to give the necessary length of travel to the high-pressure valve, has the pivot firmly secured to the frame of the engine. With this lever the crosshead engages. With the opposite end of the aforesaid lever another crosshead fixed to the front end of the high-pressure valve spindle also engages, thereby receiving its motion from the low-pressure valve spindle. In this manner only one set of motion is used for working the two valves. An important object aimed at in the design of these engines has been to make the bearing surfaces throughout as large as possible. Each of the four journals of the radial truck is 6¼ ins. diameter by 10 ins. long. The driving axle, in addition to the two ordinary bearings, which are 7½ ins. diameter by 9 ins. long, has a central bearing between the two cranks 7 ins. diameter by 5½ ins. long. In the trailing axle the bearings are 7½ ins. diameter by 13½ ins. in length.

Some interesting experiments were carried out with one of these engines at the time of their introduction. A novel pattern of double chimney, consisting of two separate channels enclosed in one casing of oblong section, was attached to the smoke-box in the usual way.

Inside the smoke-box itself a wrought-iron plate was fixed—horizontally—in such a position as to form two separate chambers, approximately equal in area. In this way the orifices of the tubes were in turn divided into two distinct groups. The foremost channel of the double chimney was provided with an extension which was carried downwards and passed through the dividing plate into the lower half of the smoke-box, whilst the second

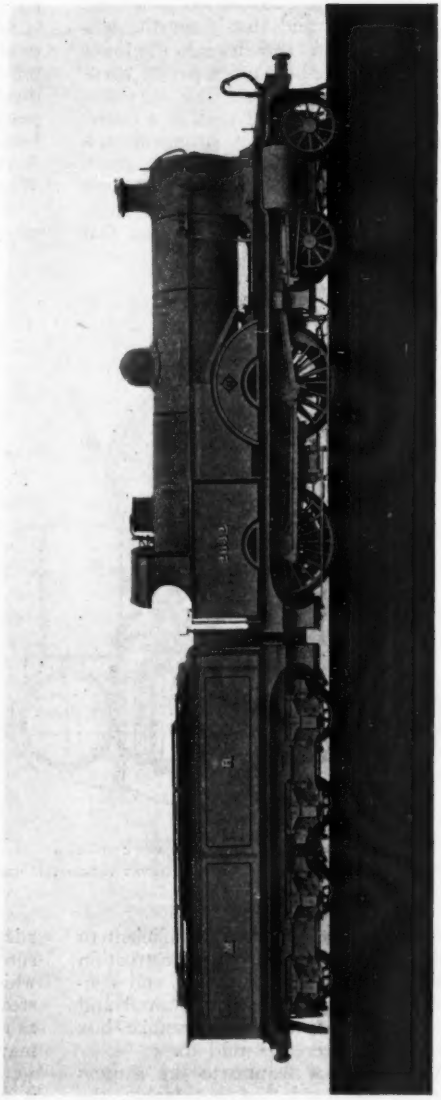


FIG. 5.—MIDLAND RAILWAY THREE-CYLINDER COMPOUND LOCOMOTIVE.

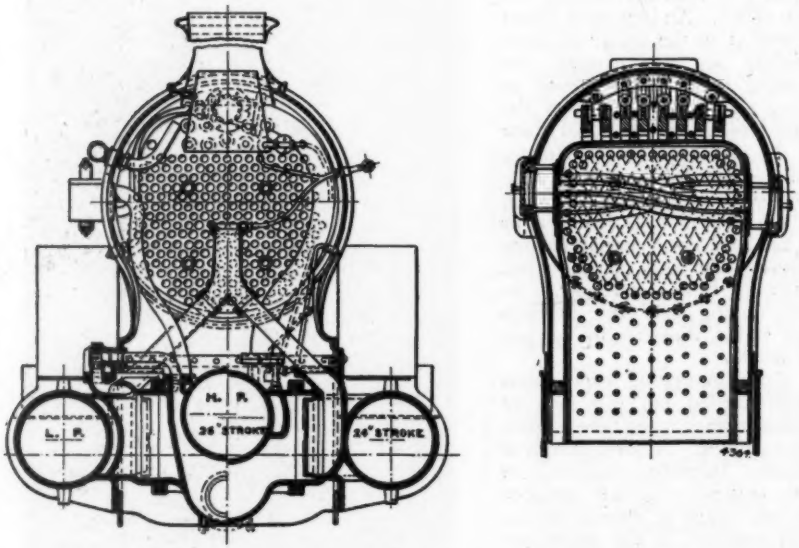
channel was open only to the upper chamber. The steam from the right-hand low-pressure cylinder was exhausted into the upper, and that from the left-hand low-pressure cylinder into the lower half of the smoke-box, two separate blast-pipes being provided, one each for either cylinder. It was hoped that, as a consequence of employing this arrangement, a more equal distribution of gases throughout the whole of the tubes, resulting in a more efficient heating surface, would be obtained, but an extended trial demonstrated that the advantage gained was not sufficient to justify the additional cost of construction entailed by this new departure, and consequently the appliance was removed and the standard chimney and smoke-box arrangements were reverted to.

A contributory feature to the success of these engines is, unquestionably, the high working pressure of the boilers. The three-cylinder compounds had their safety-valves pressed to 175 lbs. per sq. in., but when the four-cylinder engines were introduced, a further allowance of 25 lbs. per sq. in. was made.

At that time there were no other locomotives in Great Britain which were provided with boilers carrying a steam-pressure of 200 lbs. per sq. in., but the practice of so constructing them is now becoming general upon one or two railways other than the London and North Western.

It is absolutely essential that the boilers of compound locomotives should be adapted to the use of high working pressures, so that, in view of the lapse of time which must necessarily occur before the steam reaches the low-pressure cylinder, as much of its effective force as possible may be retained for the purposes of the work which has to be performed, before it is finally discharged into the atmosphere.

The principal dimensions of these interesting engines are as follows :—



CROSS-SECTION THROUGH SMOKEBOX AND CYLINDERS. SECTION THROUGH FIREBOX.

FIG. 6.—N. E. RAILWAY THREE-CYLINDER COMPOUND LOCOMOTIVE.

Cylinders (2), high-pressure				15 ins. dia. × 24-in. stroke
,, ,, low-pressure				20½ ins. dia. × 24-in. stroke
Wheels, driving and trailing				7 ft. 1 in. dia.
,, radial truck				3 ft. 9 ins. dia.
Wheel base (centre of radial truck to centre of driving wheels)				10 ft. 4½ ins.
,, (centre of driving to centre of trailing wheels)				9 ft. 8 ins.
Total wheel base				23 ft. 2 ins.
Boiler, mean diameter				4 ft. 2⅞ ins.
Length of barrel				10 ft. 11⅞ ins.
Length of fire-box				6 ft. 10 ins.
Width of fire-box				3 ft. 11 ins.
Number of tubes				225
Diameter of tubes (outside)				1⅞ in.
Boiler pressure				200 lbs. per sq. in.
Heating surface (tubes)			1241·3 sq. ft.	
,, ,, (firebox)			159·1 sq. ft.	
Total				1400·4 sq. ft.
Fire-grate area				20·5 sq. ft.

Weight of engine in working order:	Tons.	Cwts.	Qrs.
Weight on radial truck	18	18	0
,, ,, driving wheels	18	0	0
,, ,, trailing wheels	17	10	0
Total weight			

	Tons.	Cwts.	Qrs.
	54	8	0
Weight of tender in working order	26	12	0
Total weight of engine and tender in working order	81	0	0

The all-round success of the "Black Prince" class of engines was so pronounced, that when, in the spring of 1901, further locomotive power was required for working the increasingly heavy express traffic of the London and North Western Railway, Mr. Webb decided to perpetuate the type in an enlarged form. All the principal characteristics of the previous engines have been retained in those of the newer series, the chief difference being in the diameter of the boiler and high-pressure cylinders. The former has been increased by 3⅞ ins., making its outside diameter 4 ft. 6¾ ins., whilst the high-pressure cylinders are now 16 ins. diameter, in place of the original 15 ins. in the earlier engines. In consequence of the increased diameter of the boiler it has been found necessary to raise the level of its centre line 3 ins., the height from the rail being 8 ft. 1½ in., as against 7 ft. 10½ ins. in the "Black Prince" class. The number of tubes has been augmented, and is now 254, the diameter outside remaining as before, viz. 1⅞ in. The total heating surface has been increased to 1557·50 sq. ft. In general appearance the engines are identical, as will be seen by a glance at the illustrations, Figs. 2 and 3.

The class of work which is daily being performed by the engines of both series is amongst the heaviest and most trying that can be found upon any of the main lines in this country. Certain of the through Scotch expresses weigh, upon the average, considerably over 300 tons, exclusive of engine and tender, and are booked to run long distances at inclusive speeds of over 50 mls. per hour.

It is a notorious fact that Mr. Webb believes in getting the maximum of work out of his engines with the minimum spells of rest in the sheds. Before this, he has been known to keep an engine in steam and at work for a whole week without intermission, as a test of its capabilities. On these occasions it has been the practice to allot the task of running the engine to two separate sets of men, who relieve one another at regular intervals during the whole time that the engine is in steam. When it is said that the locomotives which have been subjected to this trying ordeal have, without exception, emerged successfully from it, no doubt can possibly exist in the mind of anyone as to their remarkable efficiency, both as regards design and workmanship.

Fig. 4 illustrates one of the new four-

cylinder compound eight-coupled goods engines which have recently been put to work on the London and North-Western Railway.

A numerous class of similar engines, constructed on the three-cylinder principle, have been in constant use for some few years. The general arrangement in both cases is the same, but the four-cylinder type is provided with the simplified valve gear already described. This is modified to meet the circumstances occasioned by the difference of design.

These locomotives have proved themselves to be capable of performing the heaviest class of work required of them, and still have a comfortable margin of power in reserve. Trains made up of fifty or sixty loaded trucks and weighing upon the average 820 tons, inclusive of engine and tender, are being continually hauled by them over portions of the London and North Western system.

Mr. Webb states that upon a recent occasion one of these engines took a loaded coal train, weighing 940 tons, *exclusive* of engine and tender, from Crewe to Whitmore, working up a continuous incline about ten miles long, varying from 1 in 330 to 1 in 177. If the weight of the engine and tender is added, the total would then be close upon 1,040 tons.

It is clearly recognised that they form the solution to the problem, with which all traffic managers are confronted, of how to find room for the numerous trains which it is necessary to run, in order that the business of the line may be promptly and punctually dealt with. The nett result of employing these powerful locomotives has been to reduce the number of trains to about one-half of those originally required when the maximum load was thirty or thirty-three loaded trucks. The cylinders are—

High-pressure, 15 ins. dia. by 24-in. stroke;
Low-pressure, 20½ ins. dia. by 24-in stroke.

The coupled wheels are 4 ft. 3 ins. diameter, the third pair being flangeless. The boiler contains 249 tubes, 1⅝ in. diameter outside and 13 ft. 6 ins. long. The total heating surface is 1,753 sq. ft. A new and larger type of tender is fitted, having a water capacity of 2,500 gallons.

Before quitting the subject of British locomotives, and passing on to speak of those of foreign design, a brief reference must be made to the experimental compound engines which are now being tried upon the Midland and North Eastern Railways. Both of these examples are of the three-cylinder type, and both are identical in the arrangement of wheels and cylinders; in fact, although they have been designed by the locomotive engineers of two totally distinct and independent railways, they have so many important points in common that they may almost be considered as constituting one class of engine. This is accounted for by the fact that they are both built upon the Smith three-cylinder system, which, in contradistinction to that of Mr. Webb, has two low-pressure cylinders and one high pressure, instead of *vice-versa*, as in the London and North-Western engines. A number of special features—the subject matter of Mr. Smith's patents—are incorporated in the design of these locomotives, enabling them, among other things, to be worked either as simple engines, semi-compound or compound engines. Operated as simple engines the high-pressure pistons are placed in equilibrium, whilst as semi-compounds the horse-power developed by the low-pressure cylinders is increased by admitting a certain amount of steam direct from the boiler. When working compound the exhaust steam from the high-pressure cylinder is utilised to work expansively in the low-pressure cylinders in the usual manner (Figs. 5, 6, and supplement plate).

It is claimed for these engines that—in consequence of the introduction of these special features—a wider range of usefulness is obtained than is the case with most other locomotives in present service.

Mr. Johnson's engine on the Midland is practically a repetition, in a compound form, of his previous four-coupled simple express locomotive of recent design known as the "Belpaire bogies," on account of their having boilers fitted with Belpaire fire-boxes.

It is understood that five of these engines are to be built in the near future; at present two are in use upon the northern

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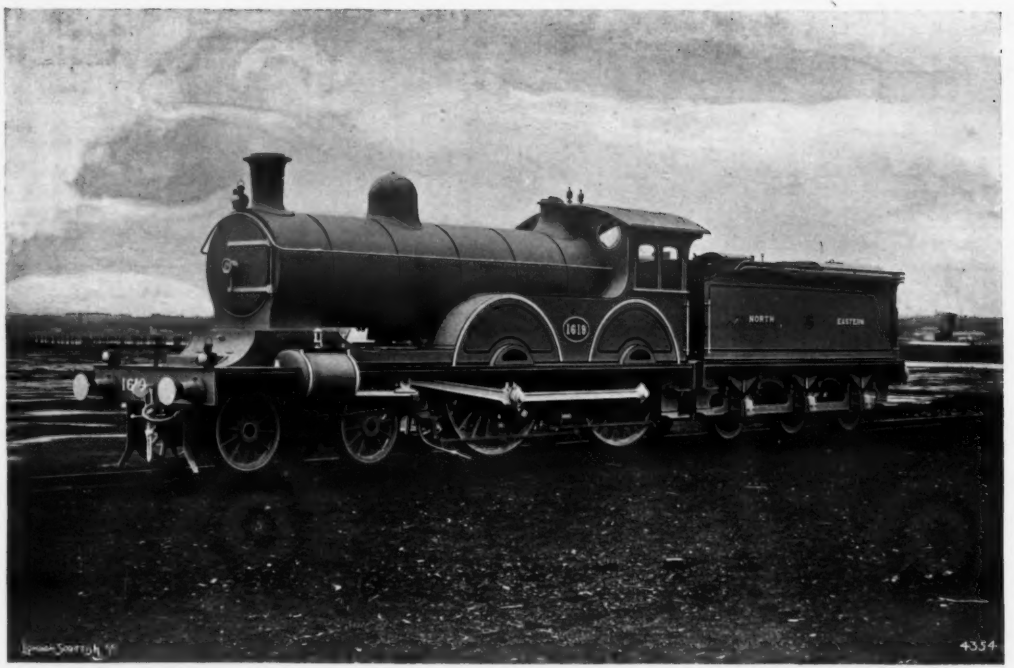


North-Eastern Railway 3-Cylinder Compound Express Locomotive. (Smith's System.)

See page 428.

division of the system. The cylinders are placed in line, with the low-pressure outside and the high-pressure between the frames, all driving on to the axle of the leading pair of coupled wheels, which in turn is coupled to that of the trailing wheels. The similarity which exists between the two engines will be observed by a comparison of the following dimensions.

Midland Engine.

Cylinders :—	
High-pressure	19 ins. dia. × 26-in. stroke.
Low-pressure	21 ins. dia. × 26-in. stroke.
Coupled wheels ...	7 ft. dia.
Steam pressure ...	195 lbs. per sq. in.
Total heating surface	1598 sq. ft.

North-Eastern Engine.

Cylinders :—	
High-pressure	19 ins. dia. × 26-in. stroke.
Low-pressure	20 ins. dia. × 24-in. stroke.
Coupled wheels ...	7 ft. 1 in. dia.
Steam pressure ...	175 lbs. per sq. in.
Total heating surface	1324 sq. ft.

One of these engines has "Serve" tubes and the heating surface is 1719·8 sq. feet.

The fire-box of the North-Eastern engine is provided with a series of cross water-tubes consisting of three groups of 21 tubes. These increase the heating surface of the fire-box by nearly 30 per cent.

Experiments are also being carried out upon the Lancashire and Yorkshire Railway with a four-cylinder compound express locomotive.

In view of the close proximity of France to England it will, perhaps, appear to be in the natural order of things that a review of what is being done in the matter of locomotive compounding in the former country should follow upon the description of the operations which are taking place in that direction at home. The statement that France is now justly entitled to be considered as the home of the compound locomotive is in no sense an exaggerated one, for with the advent of the highly successful system invented by Mons. Alfred G. de Glehn, Directeur Générale of the Société Alsacienne de Constructions Mecaniques, French locomotive practice may be said to have been completely revolutionised. Up to the time of the first engine constructed upon this principle being put to work compound locomotives were virtually unknown in France, whereas, at the present day they are in general use throughout the country. Not only the Compagnie du Nord (which is justly notorious for the high rate of speed, entailing locomotive work of the highest degree of excellence, which is one of the principal features of the conduct of the line), but also the Midi, P.L.M. Eastern, Southern, Eastern and State Railways have one and all acknowledged the superiority of the de Glehn compounds by adopting them in large numbers for various branches of service upon their respective lines.

So remarkable, indeed, has been the advance of this system that it would not be too much to say that the standard type of *modern* locomotive throughout France is the de Glehn four-cylinder compound.

The originator of this particular form of compounding claims three special points of advantage for engines which are constructed upon his principle, viz. (1) the provision for direct admission of steam to the intermediate reservoir, which enables the tractive power of the engine to be almost doubled, temporarily, should cases of emergency arise; (2) the provision of of a three-way valve by means of which the exhaust steam from the high-pressure cylinders can, if desired, be discharged directly into the atmosphere, thus avoiding excessive back pressure; and (3) the setting of the high-pressure and low-pressure cranks on either side of the engine at a relative angle of 162 degs. to one another, which assists the engine very materially when starting, and, moreover, has a beneficial effect upon the balancing of the reciprocating parts. Mons. de Glehn also asserts that he can build a four-cylinder compound express or six-coupled locomotive, of from 15 to 20 per cent. more power than an ordinary simple engine of either class at the same total weight.

The four-cylinder four-coupled ten-wheeled express locomotive illustrated by Fig. 7 was designed by M. du Bosquet, the able locomotive engineer of the Chemin de Fer du Nord for working

(besides other traffic) the exceptionally fast and heavy express trains running between the French seaboard and the capital, and it may be remarked in passing that it is mainly due to the splendid work which is being performed by the engines of this class on the other side of the Channel that the time occupied between London and Paris has been cut down to its present limit of seven hours.

As in the case of all de Glehn compound engines, the cylinders are arranged to drive two separate pairs of wheels, which are, however, coupled together, and (in the present instance) both are placed in advance of the fire-box. The leading end of the engine is supported by a four-wheeled bogie truck, and the trailing end by a pair of carrying wheels. This arrangement constitutes what is commonly known in the United States as the "Atlantic" type, and is possessed of certain advantages, one of the principal of these being the large amount of space which is rendered available for the fire-box. All the most important features necessary in a locomotive for the successful performance of fast and heavy work are incorporated in this design. The cylinder and heating surface areas are of ample proportions, the working pressure exceeds that of any other class of engines, and, furthermore, there is an entire absence of complicated details such as are, even at the present time, prominently in evidence upon some of the French railways.

Various instances have been recorded by well-known experts in matters of locomotive performance where runs of exceptional merit have been made by these engines with trains of considerable weight.

One of the most noteworthy of these is that referred to by Mr. Chas. Rous-Marten in a recent paper upon modern French locomotives, in which he relates that a train weighing 305 English tons, exclusive of engine and tender, was hauled from Paris to St. Quentin, a distance of 95¾ mls., in 90 mins. 52 secs., averaging 62·1 mls. per hour up to the 13-mile bank of 1 in 200, and never dropping below 59·2 mls. per hour on any portion of the journey, whilst on down grades the speed was rigidly restricted to 74·5 mls. per hour—the limit allowed by law in France—and

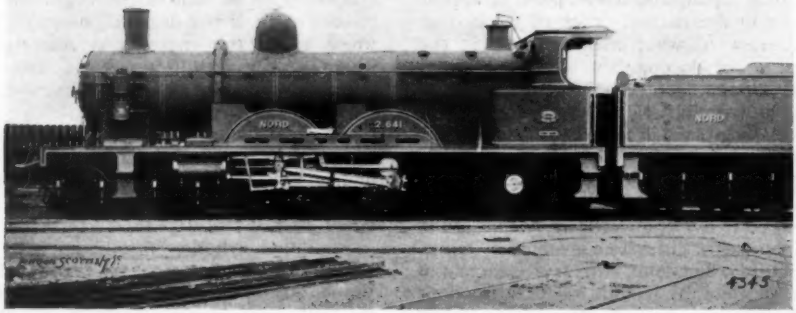


FIG. 7.—FOUR-CYLINDER COMPOUND LOCOMOTIVE: NORTHERN OF FRANCE RAILWAY.

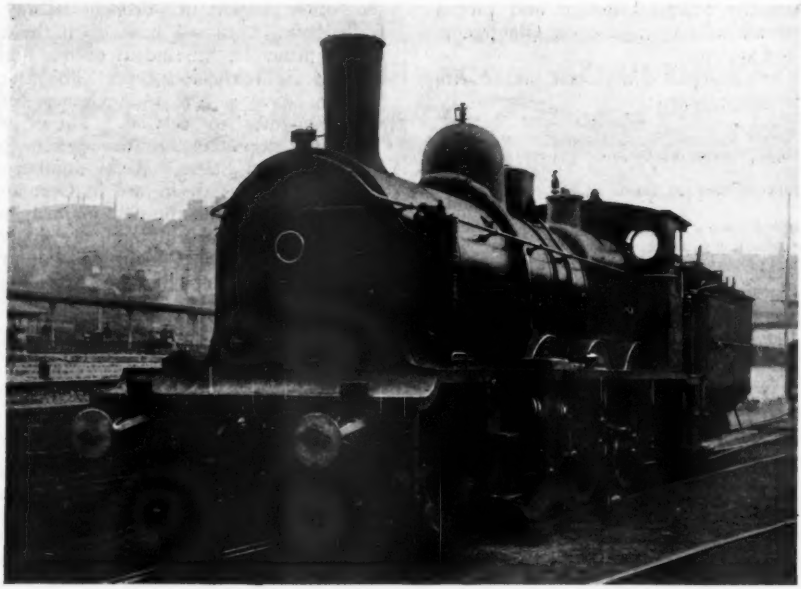


FIG. 8.—TYPE OF LOCOMOTIVE USED FOR MIXED TRAFFIC: NORTHERN OF FRANCE RAILWAY.

it was obvious that the engine—No. 2,641—could upon every occasion have exceeded this with ease.

Performances of this description at once brand an engine with the mark of the highest efficiency, and when it is further stated that they are of daily recurrence, frequently under weather conditions which are entirely unfavourable to fast running, it will be fully recognised that M. de Bosquet is deserving of a considerable amount of credit for the admirable manner in which he has adapted the de Glehn system to the type of engine, which, in the opinion of all those who understand the circumstances, is the best for dealing with the traffic conditions of the Northern railway.

The leading dimensions of the ten-wheeled express engines are as follows:

Cylinders:	
High-pressure (2), outside	13½ ins. dia. × 25½-in. stroke.
Low-pressure (2), inside	22 ins. dia. × 25½-in. stroke.
Coupled wheels	6 ft. 8½ ins. dia.
Boiler length	16 ft. 8½ ins.
,, diameter (internal) ...	4 ft. 9¾ ins.
Total heating surface	2275 sq. ft.
Steam pressure	228 lbs. per sq. in.

The total weight of these engines and tenders loaded is 108 tons. The tenders are carried upon two four-wheel bogies. Another extremely useful type of locomotive is that illustrated by Fig. 8. The Chemin de Fer du Nord possesses a considerable number of these engines, which are principally employed upon heavy excursion, fast goods, and mixed traffic trains generally.

Although they were designed primarily for hauling trains of exceptional weight at moderate speeds, they have frequently demonstrated their ability for running at high velocities with lighter loads. They are not, of course, intended for dealing with express work of the most important description.

The P.L.M., Midi and Southern Railways also own numbers of engines of

practically identical design and proportions, all built upon the de Glehn compound system.

The principal dimensions of the Northern engines are:

Cylinders:	
High-pressure (2), outside	13¾ ins. dia. × 25¼-in. stroke.
Low-pressure (2), inside	21½ ins. dia. × 25¼-in. stroke.
Coupled wheels	5 ft. 8¾ ins. dia.
Total heating surface	1250 sq. ft.
Steam pressure	213 lbs. per sq. in.

The compound express locomotives of the other important French railways, whilst being nearly all built upon the de Glehn principle, are mostly of the four-coupled eight-wheeled type. The State railways have a few four-cylinder ten-wheel engines in service. These are Vauclain compounds, and were purchased in the United States. A fair number of de Glehn engines are in use in Germany and Switzerland, but the vast majority, as is naturally to be supposed, are to be found in France, that being the country in which their introduction first took place.

(*To be concluded.*)

Chas. Lake

4368

The New Generating Plant of the Niagara Falls Power Company.

(Continued from page 339.)

THE main switchboard consists of a gallery in the centre of the building, having mounted on it 36 separate controlling panels: 11 generator, 22 feeder, 2 interconnecting, and 1 exciter panel. The relative location of these panels may be seen in Fig. 5, together with their equipment. All the switching is done on these panels by means of relay switches, placed in distinctive relation to one another, and in such a relation to imitation bus-bars placed throughout the face of the switchboard that the connections are clearly indicated, and no mistake in switching can easily be made. On the generator panels are two selector relay switches and one generator relay switch; on the feeder panels are two relay selector switches, and on the interconnecting panels are relay interconnecting switches for making the various connections between the two groups in the new power-house and between the two power-houses. On the sub-bases of the generator panels are dummy exciter bus-bars, with relay double-throw generator field switches. All these relay switches operate electrically the real switches on the power-house floor, and have the exact relation to the dummy bus-bars which the real switches have to the real bus-bars, so that even a green man could hardly make a mistake in throwing a switch. Return indicators are placed adjacent to the relay switches, so that the operator may tell at once whether the real switch has responded correctly to the movement of the relay.

There has been a considerable craze during the last few years for the operation of switchboard apparatus by bench-board control; but in designing the board for this plant the bench-board system, although carefully considered, was rejected as inconvenient. In the bench-board system the operator, in switching, must first go to the bench-board and pick out the relay switch in question; then, taking his eye off the switch, he must pick out from a concentrated mass of instruments in front of him, on entirely separate panels, the instruments involved in the movement which he is about to make. This is not altogether convenient, and there is always a chance of a mistake. It is believed that the advantages of this bench-board system are more imaginary than real.

In the switchboard installed in this plant each panel is a complete unit, and comprises all the apparatus, both switches and instruments, which are necessary for any operation which may be made upon it; so that when the operator goes to a feeder or a generator panel he has before him, enclosed within the limits of the particular panel, all the apparatus with which he is concerned at the time. All synchronising will be done by means of a Lincoln synchroniser, placed upon a swivel on the top of the switchboard.

The generator field rheostats and field switches are located under the main switchboard gallery. All feeders are equipped with recording watt meters, installed in the basement of the new office building, through which the outgoing feeders pass at the end of the cable subway.

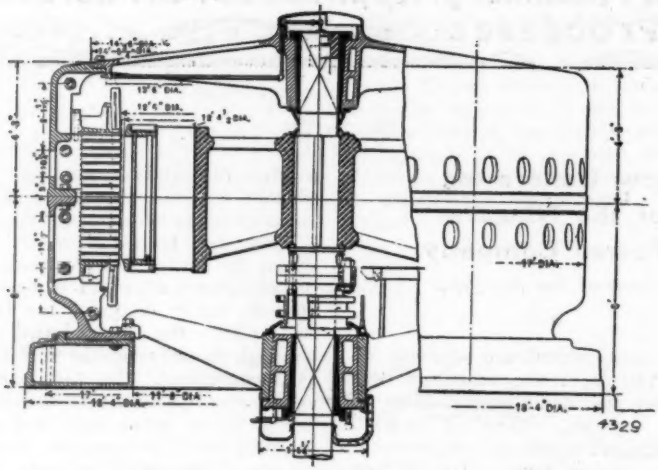


FIG. 9.—10,000-H.P. 12,000-VOLT THREE-PHASE GENERATOR, CANADIAN POWER HOUSE.

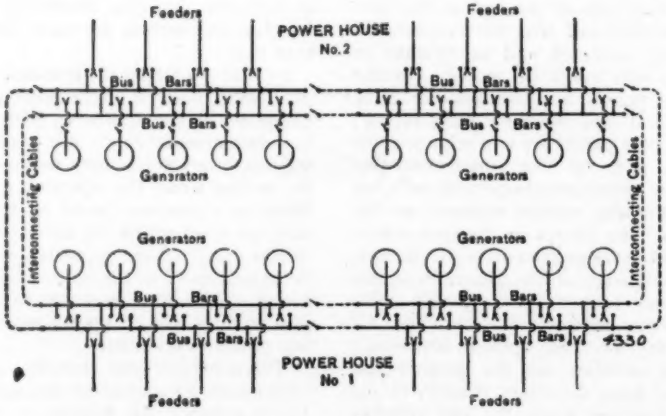


FIG 10.—SHOWING INTERCONNECTION BETWEEN AMERICAN POWER HOUSES.

It is the intention to operate the twenty-one generators normally in four independent groups; but the interconnections are so arranged that they may all be operated in parallel if desired, or any one generator may be thrown on any group. These connections are indicated in Fig. 10.

The feeder circuit-breakers will be operated by time limit relays, having an attachment devised by Mr. W. K. Gibboney, of the Power Company. A time-limit relay is a useful device for preventing a circuit-breaker from opening unnecessarily at times of momentary overloads, but if a real short circuit occurs it is objectionable. Experience has shown that on a system like that at Niagara, where there is a large amount of synchronous apparatus in operation, if a short circuit occurs it must be disconnected at once, or else the prolonged drop in voltage will cause all of the synchronous apparatus to drop out of step; whereas if the short circuit can be disconnected instantly, the inertia of the rotating parts of the synchronous apparatus will keep them in step for this short period. For this reason the ordinary time-limit relay is objectionable, since it causes a delay. The device referred to above consists of a dash-pot attachment to the tripping plunger of the circuit-breaker. This retards the movement of the plunger, and consequently the opening of the breaker for ordinary temporary overloads; but if a real short circuit occurs the pull on the plunger is so strong that the dash-pot has no effect, and the circuit-breaker opens instantly.

The Canadian Plant.

Anticipating still further increase in the use of Niagara power, the Niagara Falls Power Company has, through its allied company, the Canadian Niagara Power Company, started work on its plant on the Canadian side of the Falls. This plant will be located in the Victoria Park, about 1,500 ft. above the Horseshoe Falls. Its hydraulic feature will be similar to the American plants, with its intake canal, wheel-pit, and discharge tunnel leading to the foot of the Horseshoe Falls. This power development will be used for the transmission of power to Toronto and other Canadian cities within transmission distance, and for the transmission of power to factories located in Canada in the neighbourhood of the power-house. It will also be used for the supply of power to the American power system, with which it will be arranged to operate in parallel.

The essential difference embodied in this plant will be in the size of unit and in the electrical arrangements. The unit will be of 10,000 h.p. capacity (7,500 kilowatts), and the generators will be wound for 12,000 volts three-phase. The frequency will be retained at twenty-five cycles for the sake of uniformity with the American plants, so as to permit of parallel operation. In selecting this size of unit the American and Canadian systems were regarded as one. Since this is likely to ultimately reach an output of several hundred horse power, a unit of 10,000 h.p. is not a large proportion of the whole, and is not too large an amount of power to concentrate in one machine from the standpoint of convenience.

The principal advantage of a unit of this size over the smaller one is in the reduction in cost of development per h.p. This reduction in cost results from—

1. Lower cost of generator per h.p.
2. Lower cost of turbines per h.p.
3. A 10,000-h.p. unit occupies only slightly more space than one of 5,000-h.p. capacity, which results for a given plant output in great reduction in length of wheel-pit, power-house, and fore-bay, and a consequent reduction in construction.

Other advantages will result, such as simplicity of operation, owing to the reduction in the number of units and reduction in the cost of maintenance. This size of unit was suggested by the engineers of the Niagara Fall Powers Company, and was adopted upon their recommendation. The generators, three of which have been ordered, are being constructed by the General Electric Company.

This generator is shown in assembly in Fig. 9. It is of the internal revolving-field vertical-shaft type. Its revolving field ring is built up of punched laminations, bolted together with joints lapped

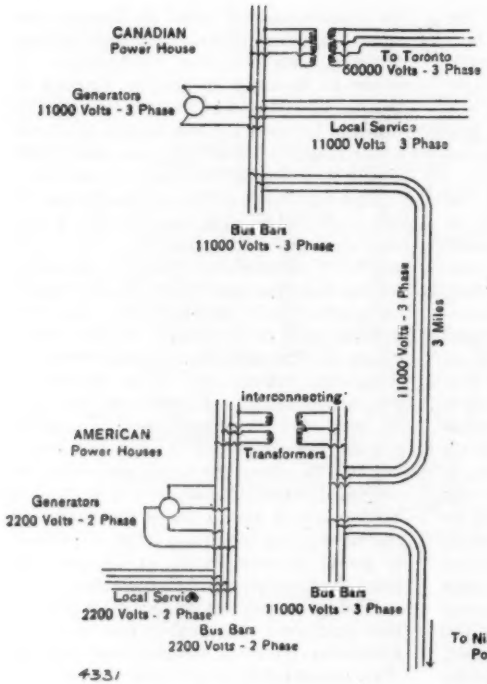


FIG. 11.—METHOD OF INTERCONNECTING AMERICAN AND CANADIAN POWER SYSTEM.

This method of construction gives a uniform and definite strength of ring and high magnetic permeability. On account of the high speed, 250 revolutions per minute, the generator is very small as compared with some of the large engine-driven units, its over-all diameter being only about 19 ft. The weight of the revolving part of the machine is 141,000lbs., with a fly-wheel effect at 250 revolutions per minute of 2,000,000,000.

The generators are wound directly for 12,000 volts three-phase instead of 2,300 volts two-phase, as in the American plants. This high voltage was selected, not for long-distance transmission, but for economy in distribution to power users near the power-house. In distributing large amounts of power underground from a 2,300-volt two-phase plant, after a radius of about one mile is exceeded it becomes cheaper to transform to 12,000 volts three-phase and distribute at this voltage than to supply power directly at 2,300 volts. From this it becomes evident that great economy results from the direct generation of the higher voltage. For long-distance transmission step-up transformers will be used to raise the voltage to 22,000, 40,000, or 60,000 volts.

Fig. 11 shows the method which will be adopted for operating in parallel the American and Canadian systems. The connection will be made by triple conductor cables carried across the upper arch-bridge over the Niagara Gorge. The paralleling will be done through step-down Scott connected transformers, as shown.

The switchboard and auxiliaries have not yet been decided upon for the power-house. It is not expected that it will be in operation for a year or eighteen months.

Polyphase Machinery for South Africa.

MESSRS. ROSLING AND FYNN, LTD., have just completed and moved into their new works at Thornbury, Bradford. They are laid out on thoroughly modern lines in spacious grounds, leaving ample room for extension.

Thornbury is within the city of Bradford boundaries, and is on the route of the Bradford and Leeds electric tramway; the works, although almost in the country, are within fifteen minutes by tram of the centre of the city, and are in a healthy and bracing situation, being some 500 ft. above sea-level; if not the largest, they

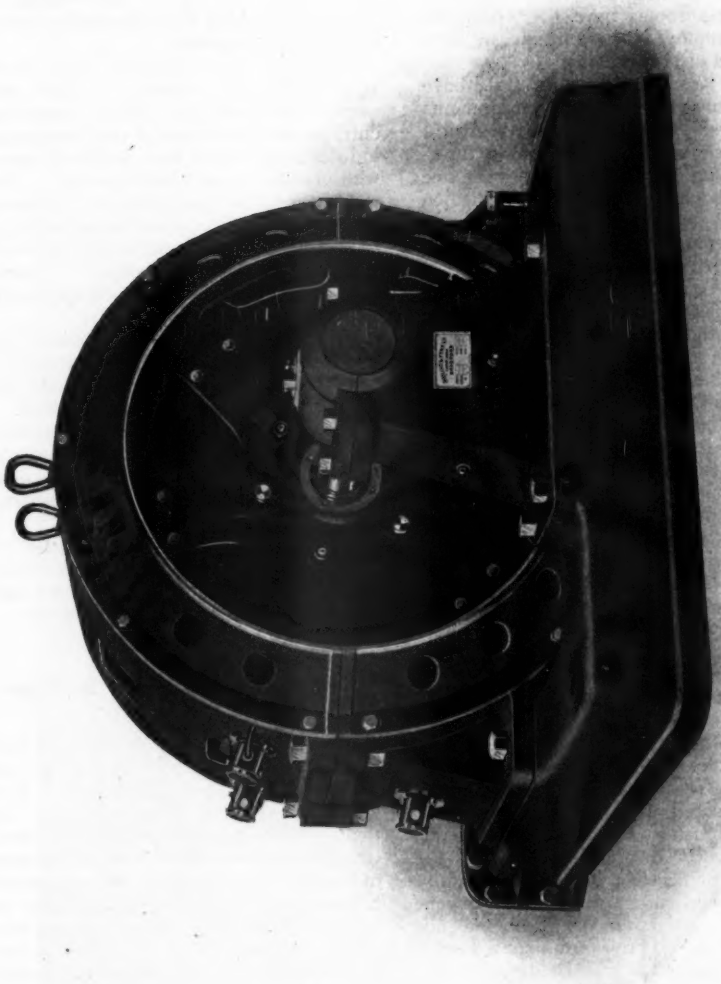


FIG. 1.—ALTERNATING-CURRENT MOTOR BY MESSRS. ROSLING AND FYNN, LTD.

are probably the highest electrical manufacturing works in the country. They will be certainly one of the most comfortable, as great attention has been paid to lighting, heating, and ventilation, and special mess rooms have been provided for the employés where they can have their meals in comfort.

Messrs. Rosling and Fynn, Ltd., have recently sent out some large consignments of electrical machinery to South Africa, amongst which may be noticed a three-phase motor generator consisting of one of their patent motors, running at 600 revolutions on a 60-periodicity 3,300-volt circuit direct, coupled to a 500 volt continuous-current generator.

The A. C. motor, of which we give an illustration (Fig. 1), is of the revolving field type, the induction being homopolar through the laminations and heteropolar through the armature coils. The field-coil is stationary, and is supported on the armature; the revolving-field is a steel-casting with laminated pole tips, held in place by rivets. The armature-coils are former wound and mechanically held in place, the usual wood wedges and similar devices being entirely avoided; as there is no moving wire, no collectors or slip rings are required. The terminals are totally enclosed in cast-iron boxes, and may be termed "fool proof."

The machine will give 150 kilo-watts as a generator at 600 revolutions, and was only selected as being the nearest standard size corresponding to the specification.

The direct-current generator coupled to it is a six-pole slot-wound machine, with laminated pole and cast-iron yoke. A heavy brush-rocker carries six sets of carbon brushes, which can all be separately adjusted and also simultaneously shifted by means of a worm. It is of the traction type and, like all machines made by this firm, has a heavy overload capacity, and is designed to run sparklessly at all loads with fixed brushes. The insulation on the armature will withstand a pressure of 3,000 volts alternating (six times the normal pressure) for thirty minutes.

It is well known that motors and generators with only one slot per pole per phase have very often been found to work unsatisfactorily in conjunction with other machines, owing to their peculiarly shaped e.m.f. curve, and such a construction is now being avoided when possible, notwithstanding its cheapness.

The curves thus obtained often show very marked odd harmonics, which give rise to more or less heavy equalising currents, and machines of the homopolar induction type often give an e.m.f. curve with unsymmetrical quarter periods. The machine under consideration, however, showed none of these drawbacks, owing to the special shape of pole, which had been predetermined with the object of eliminating these defects, and which was found to answer the purpose perfectly.

In running, the only sound emitted was due to air churning, it being quite impossible to detect any difference when the exciting current was switched on or off.

We are informed that on test the combined plant showed a low temperature rise and a very high efficiency, greatly superior to the figures given by cheap American and most Continental machines.

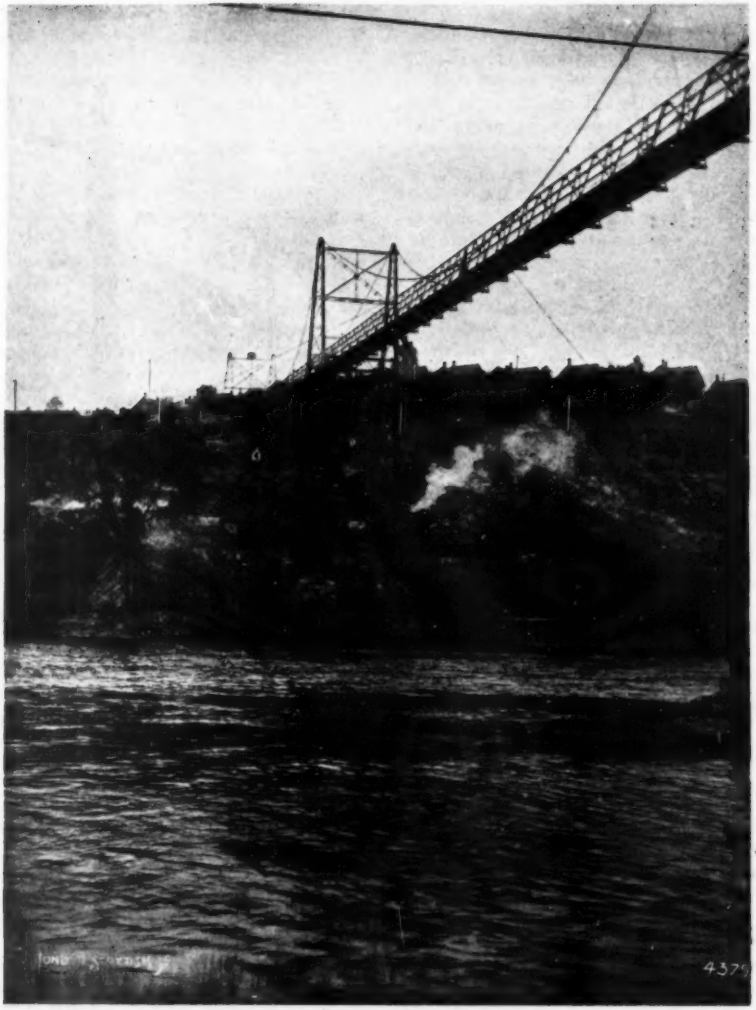
Great attention has been paid to mechanical details in these machines, as can be seen from the handsome and workmanlike appearance of the motor.

Novel Suspension Bridge.

THE accompanying photographs illustrate a suspension footbridge just completed at Easton, Pa. It is remarkable in several ways. In the first place it is built with three towers, thus forming two main river-spans instead of one, as is usually the case with suspension bridges. And it is also extraordinary on account of the great difference in elevation of the two ends, which amounts to 90 feet. To overcome this difference in elevation, the floor is run down on a 7 per cent. grade from the North bank to the river tower. From this point to the low end, are four runs of stairs, the whole being suspended from the cables.

The bridge crosses the Lehigh River,

THE EASTON SUSPENSION BRIDGE.



GENERAL VIEW OF THE EASTON SUSPENSION BRIDGE.

the Lehigh Coal and Navigation Co.'s canal, and four tracks of the Lehigh Valley Railway. Its total length is 804 ft. It contains two river-spans of 279 ft. each, and a stair span of 110 ft.

On account of its having only a 10 ft. roadway, which is small in proportion to its length, it was necessary to resist wind pressure by running guy ropes from the centre of the two main spans to shore.

As will be seen from the illustrations, the bridge has steel towers, resting on stone piers, which are built up to extreme high-water level. The height of the centre tower, from low water to top of saddle, is 108 ft. It has two steel-wire cables, $2\frac{5}{8}$ in. diameter each, and $\frac{3}{4}$ in. suspenders. The steel stiffening trusses are 5 ft. 3 in. deep. They are braced laterally at panel points to the floor beams. It has wood joist, plank floor, and wood hand-rail.

The placing of the masonry anchors on the low side gave considerable trouble, as the water soaked through the loose material from the river.

It is a toll-bridge, owned and operated by a local company. In the autumn of 1899 the owners advertised for plans and estimates, and the design shown herewith was accepted. The City Engineer of Easton had charge of building the foundation.

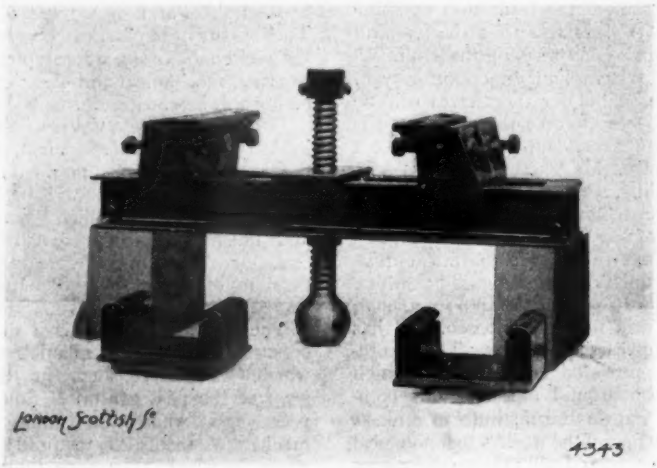
The bridge, including both substructure and superstructure, was designed by the contractor's engineer, Mr. H. G. Tyrrell of Boston, Mass.

Wilson's Ship Plate Dent Extractor.

THE accompanying illustration is that of an apparatus which has been designed for straightening out indentations frequently caused in barge or ship-plates by collision or impact of some kind.

The employment of this apparatus obviates the necessity of removing the plates and prevents the starting or loosening of the rivets such as often occurs when the plates are subjected to a hammering process.

The apparatus is fitted in the following manner: the twin clamps on the bed being traversing, they can be adjusted to the width of the ribs, and by tightening the four set screws of each clamp the apparatus is thereby held in position. The vertical



WILSON'S SHIP-PLATE DENT EXTRACTOR.

sides of each clamp are outwardly flanged, such flanges having slots cut therein to permit of bolts being driven through them into the side of the ship or barge. The indentations are removed by then bringing a steady pressure to bear on the damaged part by means of the force screw, which is capable of being adjusted in both a vertical and lateral direction. In the event of the ribs becoming bent, by removing the twin clamps and slipping the adapters (shown at the foot of the illustration) on the bed of the apparatus and then fixing the clamps on the adapters the machine is brought into a perpendicular, when the force screw can be applied to the bent part.

The machine can also be used for bending or straightening angles, tees or bars.

Manchester Municipal Technical School.

THE new Municipal School of Technology was opened on Wednesday, October 18th, by the Prime Minister. It cannot be more aptly described than in the words of Mr. Balfour, who represented the institution as being "perhaps the greatest fruit of its kind of municipal enterprise in the country." Those who have had an opportunity of seeing the school for themselves will be quite ready to endorse this view, as it is one of the finest and most magnificent structures that Manchester now possesses. The building, which is an example of the French Renaissance style, is a magnificent structure of red brick and terra-cotta, and occupies an area of 7,300 sq. ft., exclusive of a subsidiary textile building, which covers a further space of 1,248 sq. ft.

It has cost nearly £300,000, and has been seven years in building. The accommodation provided is on a scale which will, on the ground of scope and completeness, entitle the institute to rank as one of the first of the world's technological establishments, and will remove the stigma that has been attaching to many others of this country when compared with those of Germany or America.

The ground floor contains, in addition to the spacious entrance hall and the administrative offices, class-rooms and laboratories connected with the physics and textile departments. The principal feature of the first floor is the large examination hall, in which the speeches connected with the opening ceremony were delivered; and adjoining this are the library and reading rooms, a room for scientific societies' meetings, laboratories, class and lecture rooms for electrical, mechanical, and sanitary engineering, and the lecturers' common room. The second floor contains lecture rooms and laboratories in connection with architecture, the photographic and printing crafts, and the electrical trades. An experimental bakery, students' common room, and restaurant are also provided on this floor. The organic and inorganic chemical laboratories, the principal chemical lecture theatre, laboratories for metallurgy and brewing, and the woodworking and plumbing workshops are placed upon the third floor; and on the fourth are the dyeing laboratories, an experimental brewhouse, and a well-equipped gymnasium. There are in addition an observatory, a house-painting and decorating department and rooms for bookbinding and lithographic drawing. The basement is practically a great workshop and laboratory, where spinning and weaving, mechanical and electrical engineering will be carried on.

For the accommodation of the textile industry a special department, adjoining the main building, is now in course of construction. In this will be provided a commodious dyeing, bleaching, printing, and finishing house for textile goods, and for the manufacture, dyeing, and finishing of paper. This department will not be completed until January next.

The present institute is a direct successor of the old Mechanic's Institute, which was established in the early years of the past century. Some twenty years ago, when the failure of the mechanics' institutes to fulfil the purposes for which they were intended was beginning to become recognised, an offer

VIEW OF THE NEW MUNICIPAL SCHOOL OF TECHNOLOGY, MANCHESTER, LOOKING FROM THE CORNER OF SACKVILLE STREET—GRANBY ROW.

was made by the City and Guilds of the London Institute to the Mechanic's Institute of Manchester, to the effect that they would give a small annual subvention, and an additional grant for apparatus, if the management would change the Institute into a technical school, under a scheme to be provided by the City Guilds. The offer was accepted, and it was thus that the Technical School of Manchester came into existence.

Manchester will be indeed fortunate in the possession of such a commodious and admirably equipped building, and in the advantages accruing from such well-arranged courses of instruction, which have received the highest approval from Continental and American experts; and it is to be hoped that this example will be speedily followed in other manufacturing centres.

Space will not permit of a thoroughly detailed description of the plant and apparatus which has been installed throughout the building being given. It will suffice to state that the equipment has been provided in a most thorough-going manner, and the facilities afforded for genuine instructional work and independent research leave nothing to be desired. The latter feature has been more particularly kept in view, as one of the prime objects of the institution consists in affording facilities to experts and leading authorities for the investigation of problems of present importance to the engineering community. Full advantage is likely to be taken of these opportunities, as, for example, on the occasion of our visit a series of experiments were being conducted with a new rapid-cutting steel recently placed on the market, the results of which investigation will be shortly announced before one of the engineering societies of the district.

In the steam engineering department, situated in the basement, is a very fine 350 b.h.p. experimental engine by Messrs. Jas. Carmichael & Co., of Dundee. It is of the horizontal compound-condensing type, with cylinders 11½-in. and 20-in. diameter, by 36-in. stroke, and is made to run either compound or simple, condensing or non-condensing. Both cylinders are fitted with Corliss valves and gear, while two other interchangeable cylinders have been provided, these being fitted with Meyer gear and Sulzer drop-valves respectively. The fly-wheel, which is fixed centrally on the crankshaft, is fitted with a special form of band-brake, consisting of two pieces of steel riveted together, with a space left in which water is allowed to circulate. The engine is specially fitted for the study of the distribution of wall temperatures in the cylinders, and for the observation and measurement of leakage.

A 60-h.p. Ball and Wood engine, with simple, high-speed, automatic cut-off, exemplifies American practice. In the laboratory there is a two stage 40-h.p. air-compressor, fitted with various types of valves, and driven by the electric motor which is roped to the Gwynne pump. This air-compressor is by Steven & Struthers, Glasgow.

Adjoining the steam laboratory is the electric generating plant for supplying current for lighting the building, and power required in the various laboratories.

The engines and dynamos in this station, all of different types, are also available for experimental purposes and research. The sets are made up in the following way—

1. A compound engine by Messrs. Marshall of Gainsborough of the side-by-side cylinder type, connected by a rope-drive to a 100-k.w. four-pole shunt-wound dynamo by Messrs. Ernest Scott & Mountain.
2. A high-speed compound engine by Messrs. Browett, Lindley & Co., coupled direct to a 100-k.w. direct shunt-wound dynamo by Messrs. Mather & Platt.
3. A Willans high-speed engine direct coupled to a Bruce-Peebles, 100-k.w. dynamo.
4. A tandem compound of the overhung crank type by the Robb Engineering Co., driving a four-pole dynamo by Messrs. Dick, Kerr & Co.
5. A 50-k.w. Parsons' turbo-electric generator.

There is a fine switchboard by Messrs. Cowan's, Ltd.; beneath the gallery carry-

ing this being situated a balancer and booster set by the Lancashire Dynamo and Motor Co.

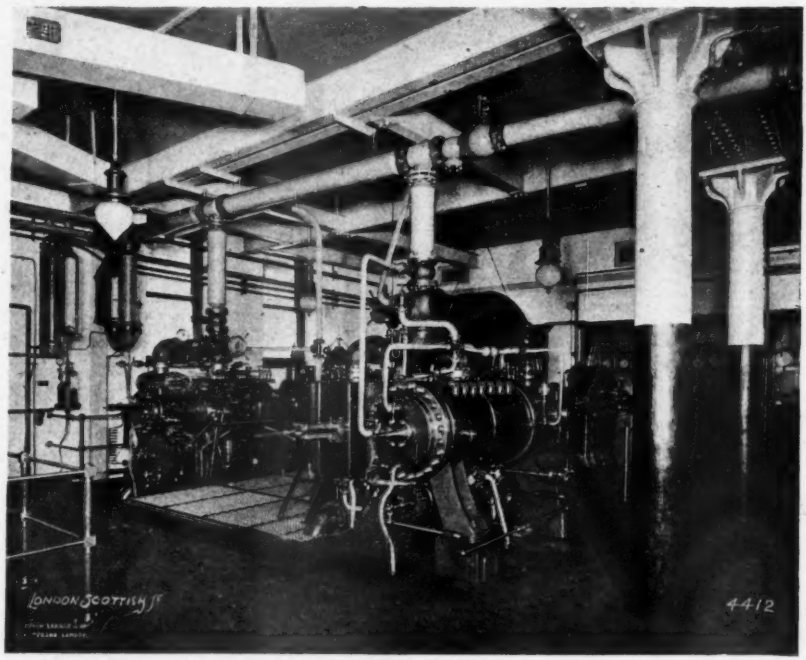
To complete the central station equipment there is a battery-room containing storage cells of 600-ampère hours' capacity.

Steam is supplied to this plant by three boilers, all of different types, the first of which is a Babcock water-tube boiler of 200-h.p. capacity under forced draught; the second of the return tube type by Messrs. David Rollo & Sons, Liverpool, with a capacity under forced draught of 450 h.p.; while the third is of the small tube express type of water-tube boiler.

Mechanical stokers are fitted to two of the boilers, and a Schmidt superheater has also been installed.

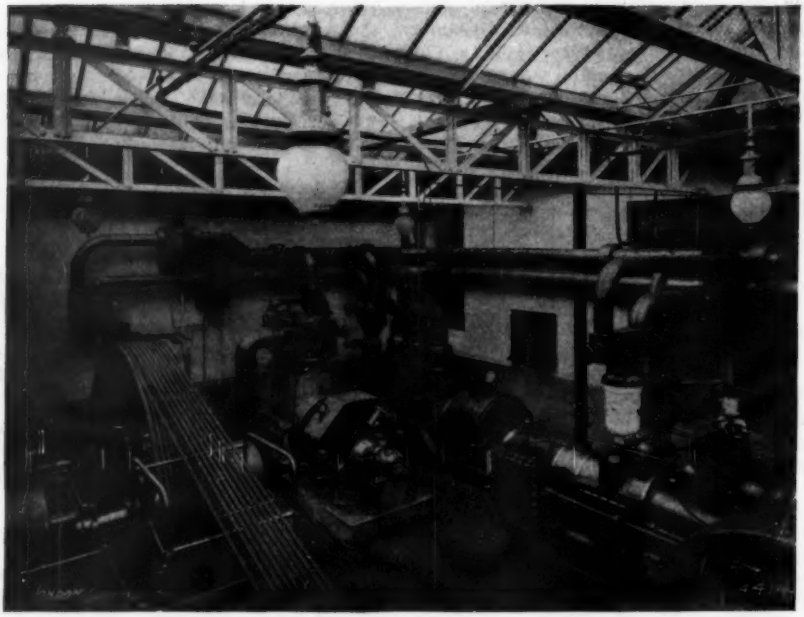
The engineering workshop has a very complete equipment of modern machine tools, a good many of which are of American origin. A particular feature of this department is the up-to-date arrangement of a special tool room, in which a complete installation of fine-grinding machines offers facilities for carrying out standardized work according to modern methods.

The smithy contains 11 forges, a large hearth and steam hammer, while the foundry and wood-working shops are well equipped.



THE HORIZONTAL COMPOUND CONDENSING EXPERIMENTAL ENGINE.

In the Materials Testing Laboratory there is a 25-ton Amsler-Laffon tension machine; a 30-ton compression and a 30-ton beam-bending machine, by the same makers, taking beams up to 14-ft. span. There is a 50-ton Wicksteed horizontal testing machine, taking in specimens up to 9 ft. long in tension or



A VIEW OF THE ELECTRIC GENERATING STATION.

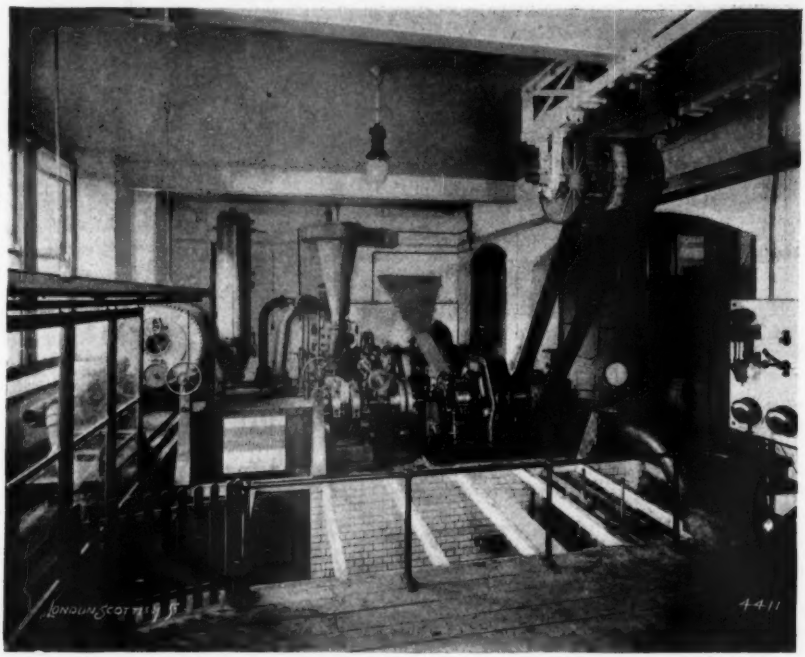
compression. There is also a compression press of a capacity up to 750 tons for crushing brick and masonry piers, and the like. The machines are operated from an accumulator supplied by an automatic-pressure intensifying pump.

The Hydraulic Laboratory is fitted up on an extensive scale. There is a high service tank on the roof of the building, containing 13,000 gals. of water, from which 12-in. pipes carry the supply to one or other of three 20-h.p. turbines of the Girard, Thomson & Francis types. The discharge from the turbine after being stilled flows over a 4-ft. weir, and returns by a channel 110 ft. long to volumetric measuring tanks in the sub-basement, from which the water is returned to the high tank by a 12-in. twin series centrifugal pump by Gwynne, driven by a 220-volt 1,000-amp. electric motor, by the Lancashire Dynamo and Motor Co. Thus a 20-h.p. turbine, using 300 cub. ft. of water per minute under heads up to 100 ft., can be kept going for many hours, under experiment, by using the same water over and over again. The equipment in this laboratory further includes a V-channel for the study of the flow of water in pipes and channels at varying inclinations, length 110 ft., capacity up to 3,000 gals. per minute; and a large experimental pump driven by a Schuckert 220-e.h.p. electric motor. The pump, by Frank Pearn & Co., of Manchester, is intended for investigations, after the manner of Bach, on the action of various types of pump-valves. This pump will also supply water under pressure up to 300 lbs. per sq. in., at the rate of 300 gals. a minute, for experiments on jets and on the flow of water through pipes, valves, and cocks, and against vanes. Two of the turbines, and a Pelton wheel, are by Gilbert Gilkes & Co., and the third turbine by Hemmer Bros., of Neidenfels. The large measuring tanks and the pressure tank are by George Scott & Sons, of London.

The Machine-testing Laboratory is intended for making experiments on the efficiency of machine-tools, and is at present occupied by a fine 18-in. lathe, lent by Armstrong, Whitworth & Co., for the special work of testing rapid-cutting steel. The laboratory is fitted with ordinary and roller-bearing shafting, and will be used for testing belt, rope, and chain drives by means of dynamometers of various types.

In the Gas and Oil Engine Laboratory are installed: a one ton ammonia refrigerating plant, by Linde; a one ton carbonic anhydride plant, by J. and E. Hall, of Dartford; a 20 b.h.p. gas-engine, by Crossley Brothers, driving a dynamo by Crompton, which may be direct connected, or alternatively; and a blow cylinder for supplying measured quantities of air to any of the gas or oil engines. There are also a 20 b.h.p. gas engine, by the National Gas Engine Co., a Fielding and Platt oil engine, and a Hornsby-Akroyd oil engine, all fitted with thermometer holes or thermo-electric junctions in the walls for temperature measurement. Callendar recording platinum thermometers are supplied for taking temperatures in the working fluid of these explosion engines.

The Mechanics' Laboratory is most completely equipped with apparatus for teaching the principles of the subject experimentally after the manner of Professors Perry and Ewing; and work of an advanced character can be carried on there during the course for the second year. In the Engineering Physics Laboratory, students receive instruction in methods of higher research on such matters as the rate of condensation and re-evaporation of steam, the transition of heat across metal surfaces as affected by



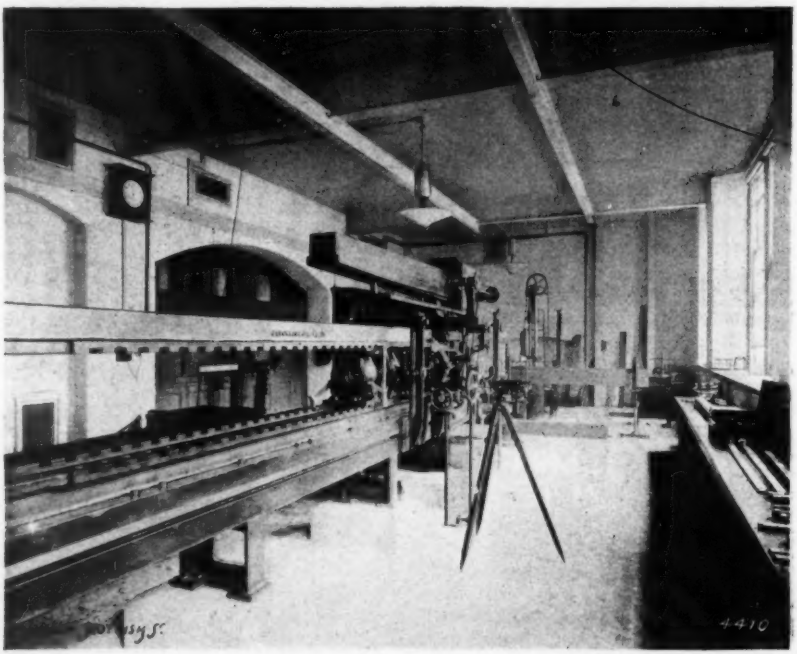
THE HYDRAULIC LABORATORY.

speed of circulation, and the properties of the various working fluids used by the engineer.

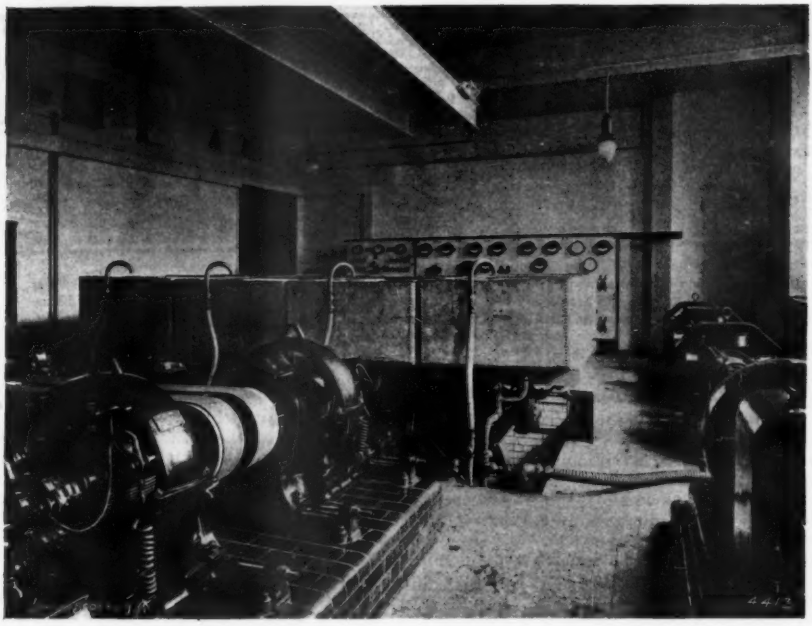
In the electrical engineering department the laboratory and testing rooms are equipped with the most modern English, American, and Continental plant and appliances. The department contains two lecture rooms, four laboratories for work in physics and electrotechnics, a research laboratory, two dynamo and motor testing rooms, a standardizing laboratory, a high-tension room, electrochemical, photometric, and optical laboratories, instrument-testing, cable-testing, and experimental accumulator rooms.

The electrical plant for supplying the building with current for light and power is, under suitable conditions, available for testing purposes. It includes, in addition to the plant before mentioned, three 50-k.w. experimental machines by Schuckert, coupled together; a 30-k.w. three-phase generator, of rotating-field type; a ten-ton electric tramcar, body complete with motors, controllers, etc, mounted on friction wheels for experimental purposes, a view of which is given; two single-phase inductor alternators, of 15 k.w., driven by two 220-volt continuous-current motors; a 15-k.w. three-phase generator, coupled direct to a 400-volt continuous-current motor; two 5 k.w. rotary converter sets, with transformers, switchboard, etc.; a triple continuous-current set of 15 k.w., fitted with slip rings, and specially designed for experimental work; a 10-k.w. Edison-Hopkinson continuous-current dynamo, coupled to a 10-h.p. steel-clad motor, and a motor generator giving 100 ampères at 20 volts.

The department contains upwards of 30 continuous and alternating current motors, of various types, available for



A VIEW IN THE MATERIALS TESTING LABORATORY.



THE EXPERIMENTAL ELECTRIC TRAM-CAR.

testing, varying in size from ½ to 200 h.p. These are in addition to the large installation of electric motors for driving the tools and machines throughout the school.

A special high-tension room is furnished with a 20-k.w.-transformer set, with a still well regulator for voltages up to 100,000, and with experimental transformers of different types.

The laboratories are all supplied with continuous, alternating, and three-phase currents at various tensions, and contain examples of all the most modern forms of electrometers, galvanometers, potentiometers, wattmeters, voltmeters, ohmmeters, and other testing instruments.

They are furnished also with sets of standards, of English, French, and German make, of resistance, electro-motive force, and current.

The photometer room is equipped with a Letheby-Bunsen standard photometer bench, photometers of the Lummer-Brodhun, Steinheill, and Krüss types, together with pentane, amyl-acetate, Methven, and Carcel standards.

(To be concluded.)

Workshop Practice

Practical suggestions for this section are invited, which, if accepted, will be suitably paid for. Wherever possible, drawings should accompany the contribution; rough sketches will suffice. Nothing will be too poor for a careful inspection. See important announcement in advertisement pages.

A Few Useful "Helps."

WHEN setting out the positions for bolt-holes or studs in cylinders or other circular work, it is usual to bridge the space or bore with a strip of timber, on which the centre is located and sometimes prevented from becoming enlarged by a piece of tin held down with a few tacks. The finding of tin and tacks is sometimes a long job, and a small brass disc about an inch diameter by $\frac{1}{8}$-in. thick, having a couple of small holes for screws, will be found a very useful accessory. A small indent is accurately made in the centre, whilst its diameter and form is a handy one to mark off other dimensions. Fig. 1, for millwrights or others doing repairs to shafting, hangers, etc., is a piece of timber 6 ins. or 8 ins. ong planed up parallel to 2 ins. square, with a hole or pin in the centre at one end from which hangs the plumb-line. With this simple appliance reference marks can be made on the ceiling, or measurements taken in a longitudinal or lateral direction, as the distance from the centre of the line to the edge of the block, being unity, is easily remembered. Fig. 2 is a piece of brass wire, $\frac{1}{8}$-in. or $\frac{3}{16}$-in. diameter, with each end turned up as shown. The use of this is an advantage over the common method of winding a line on a bobbin or stick, and in the case of falling, the unwinding is prevented by the line being caught in the bent ends.

THOS. SPEERS.

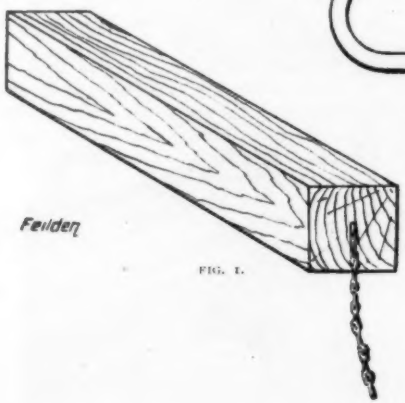


FIG. 1.

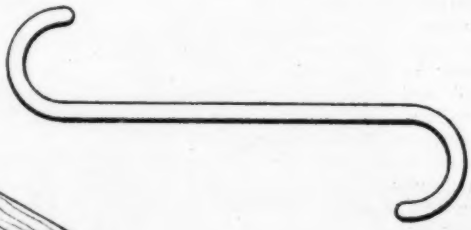


FIG. 2.

A FEW USEFUL "HELPS."

Boring Wood Bowls.

The end and back elevations (Figs. 1 and 2) show an attachment for the holding of the bowl during the boring operation. In connection with a large firm of calico printers, a great number of sycamore bowls are used; and we have several times experienced great difficulty in holding these on the lathe carriage sufficiently firm to give satisfactory results, consequent upon their large diameters and great length. We therefore found it necessary to make the attachments as shown, and which consist of two saddles provided with T slots, the latter for the purpose of bolting down the screwed standards *S S'*, which support the wrought-iron angle-clips *B B*. The saddles are provided with loose strips which admit of their removal from any part of the bed. In the case of long bowls a couple of saddles are used, as in Fig. 2, and in short ones the standards and saddles are brought close up, and coupled to the carriage by plates and bolts.

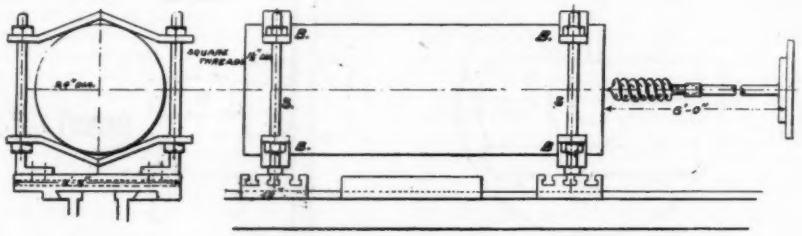


FIG. 1. FIG. 2.

BORING WOOD BOWLS.

A. T. METCALF.

Boring and Turning Eccentrics.

Any short bushes or studs may be set eccentric for boring or turning, similar to the method described on page 81, January No. of the Magazine, but the following method will at times be found more convenient and more accurate. Let us assume we are to make an eccentric bush, as shown at *A*. For setting purposes an auxiliary plate *B* is used, into which is fitted a taper shank coinciding with the hole in the bush. Before fixing the job on the face-plate two parallel lines are scribed on the plate *B*, which may then be held by a strip *D* on one edge of the plate to form a bearing during adjustment. The outside diameter is then turned from ·02 to ·025 above the finished size. A gauge *E* is then required, having two ends, the difference between each being very accurate, and equal to twice the eccentricity of the hole to be bored. For very accurate work the gauge is best hardened and ground to the exact sizes, and may then be used for other work having the same variation in sizes. A stop *F* should then be fixed in the slide-rest and the cross-feed screw wound up, until the large end of the gauge just slips between stop *F* and bush *C*; then move the job along the strip *D* to half the difference between large and small end of gauge, or the required eccentricity of bush. Next move the feed screw until the small end of gauge just makes contact between stop *F* and bush *C*. Give the lathe face-plate half a turn, and try the large end of gauge between the stop and bush; if not correct, move the auxiliary plate to half the error, then test again until correct to one or two-thousandths. The hole should then be rough-bored, re-centred, and outside diameter finished. Then carefully throw out again, as before, repeating operation of setting until satisfied as to the accuracy; finish the hole to exact sizes. The plate *B* should be gradually tightened up as the adjustment is made. Standard or master bushes made in this manner may be used for turning or grinding eccentrics, mandrels, etc., or in connection with jaw, cam, or spring chucks, when turning spindles, punches, or other similar work.

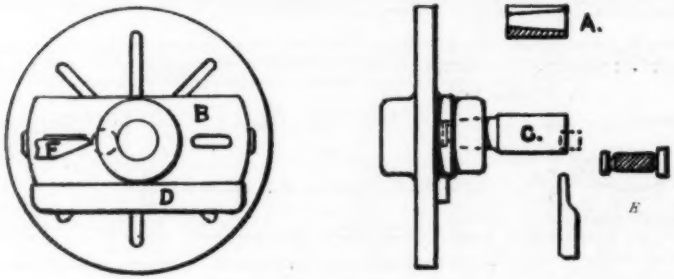
H. HELLFRITSCH.

Replacing Worms of Odd Pitches.

Having to replace a worm, and being unable to get the necessary pitch with our change wheels, the following method was adopted:—The worm casting, which was made slightly shorter on the working part than the original (to allow for starting and finishing the cut), was bored and keyed on to a mandrel, together with the old worm. A double-ended toolholder, having a cutting

tool in left-hand end, and steel guide (filed to suit thread of old worm) in the other end, as shown, was employed to obtain the necessary traverse of saddle. The steel guide projected about $\frac{1}{4}$ in. farther than tool when starting to cut, and the tool was advanced in the tool holder until the full depth of the thread was reached.

H. M. A. and A. P.



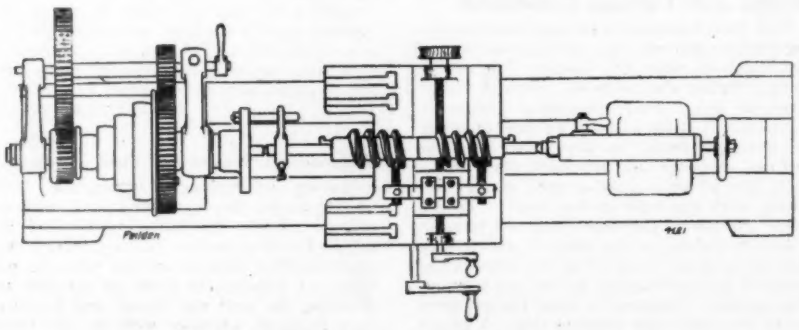
BORING AND TURNING ECCENTRICS.

An Improved Method of Manufacturing Copper, Yellow Metal, and Naval Brass.

In the manufacture, hitherto, of copper plates, sheets, bars, bolts, and hoops, the crude material, such as Blister, Chili slab and other pig copper, or mill-scrap, has been refined in the refining furnace, and thence ladled into pots or moulds, in the form of cakes. These, of which there are usually four or five cast into each pot, are afterwards allowed to cool down before they are removed from the moulds, generally not until the next day, so that the heat that had been contained in the whole furnace charge of copper plates is absolutely wasted.

The new process consists of the utilisation of this heat, resulting from the refining operation, for the purpose of rolling the metal in the "breaking-down" and "drawing-on" stages, thus doing away entirely with any reheating in the heating furnaces usually employed for these operations in the existing mode of manufacture.

For the purpose of facilitating the new process, and for treating the cakes or plates whilst still hot from the moulds, they are ladled, as usual, from the refinery furnace, but singly, into specially constructed reversible and tipping or other detachable moulds, which have permanent copper plates for their bottoms, and which, of course, receive the usual preparatory wash, etc., before the molten metal is ladled into them. From these the cakes, plates, or bar ingots



REPLACING WORMS OF ODD PITCHES.

are quickly ejected or stripped, as soon as they are set, thus doing away, in the first place, with the thin layer or bottom of copper, which is, at present, always at first cast into each pot or mould, before the cake itself is ladled on to it. The process of casting these layers or bottoms, and the subsequent remelting of them, is thus rendered unnecessary, and the net yield of the refinery furnace is increased.

In the new process, the cakes, plates or bar ingots, when properly set in the moulds, after having been ladled from the refining furnace, would be then immediately tipped from their moulds (the heavier plates having their mould sides stripped) and then conveyed either by a suitable crane, overhead run, or by cars, without loss of time, direct to the "breaking-down" rolls, through which they would be passed several times, and subsequently, if it should be so desired, to the "drawing-on" rolls, where the rolling would also be fully carried out, or to a large extent.

The whole of the rolling, up to this stage, would be thus accomplished by means of the heat left in the copper from its original molten condition in the refinery; thus it will be seen that two distinct re-heatings are obviated and entirely done away with.

After the rolling in the "drawing-on" rolls is completed, the sheets, etc., are treated as usual in the existing mode of manufacture; they are allowed to cool, sheared on the edges to weight, and are now ready for being heated in a furnace preparatory to being rolled in the finishing stage in the "finishing" rolls; so that this latter re-heating would usually be required only in the new process for the bulk of general work; but even this may be dispensed with also in a large number of products such as hoops, or heavy bars and plates, as these can be "finished" completely and quite easily, as far as the rolling is concerned, by means of the original refinery heat.

Now, in the frequent re-heating which is practised in the existing method, unless great care is exerted, the copper often becomes overheated and is burnt in places through irregular heating (this being often the cause of many after complaints, and being usually attributed to bad quality of the copper), and if the workmen have been very negligent, a large amount has to be taken back to the refinery to be re-melted and refined afresh. The risk of such waste and expense would be nearly altogether avoided in the new process on account of the refinery heat being taken advantage of instead of that due to heating furnaces, this being found to be quite sufficient to carry it through all the preliminary rolling stages, and at the same time to be highly suitable, the interior of the metal being hotter than the exterior portions, and so quite reversing the present conditions of heating. Further, in heating furnaces much grit, dirt and dust are gathered by the products which are being heated, this being carried over by the draught from the fireplace, resulting in a great deal of chipping and scraping in consequence of the general roughness and specks on the surfaces and of the burnt parts. All this also would be avoided in the new process, as well as a very important diminution of the great waste caused by oxidation of the surfaces of the material taking place through the continual heating and cooling which they undergo at present, and so again effecting considerable saving.

With the existing process it is found sometimes that some of the cakes being ladled, forming part of the refining furnace charge, have lost the "tough pitch," probably through the furnace having "gone back," and are not therefore up to the rolling quality, and have consequently to be sent back to the refinery to be remelted and refined afresh. The risk of this waste is prevented in the new process, as this circumstance could not occur, for the reason that the loss of quality in any particular cake being ladled would be immediately discovered by the rollerman manipulating at the rolls, by its behaviour in withstanding the rolling stress, and so affording the refiner the time and opportunity, if the quality is not up to the mark, of altering or improving the "pitch" in the bath of the refining furnace before other cakes were ladled out, the rolling, in fact, being a continuous test or proof for the refiner's guidance.

Finally, the new system would have the effect of enabling the workmen and the machinery to vastly augment the yield of the mill, and to cause orders to be executed with much greater dispatch, and more especially so in the case of those articles which can be finished completely, as far as the rolling is concerned, by means of the refinery heat only.

The process described above is also in its main features applicable to the manufacture of alloys, such as yellow metal, naval brass, and the like, which are mostly rolled in a hot state. These metals, or mixtures, whether melted in furnaces or in crucibles, would be, by the new mode, subsequently poured into suitable tipping or other detachable moulds, in the shape of plates or bars, and as soon as they were sufficiently set, would be immediately stripped from the moulds and conveyed, without loss of time, to the rolls, where they would be "broken-down" and, if necessary, sheared hot, and then "drawn-on" for

most of general work. They would then be allowed to cool, and be ready for treatment in the ordinary way in the finishing stage. All this work would have been advanced so far by simply utilising the heat contained in the plates or ingots immediately after being cast, thus enabling all the rolling to be performed (excepting only that of the finishing stage) without any reheating of the metal, so that, as in the case of copper, before mentioned, a very important saving of labour, fuel, time, plant, and space is again effected, as well as the avoidance of any risk, with its attendant expense, of remelting of plates, which may happen when the metal has been mixed in furnaces, in consequence of the different proportions of the different metals in the alloy being sometimes lost through the excessive volatilization of the spelter therein. This would be at once detected at the rolls on its arrival there, by the rolling of a single plate, before others were cast into the moulds, and in time, if the proportions or the pitch is not right, to rectify the mixture at once, instead of incurring extra expense, through casting the whole furnace charge into the moulds as plates, and allowing them to cool down before work of any kind had been performed on them to discover their rolling quality, this latter being only found to be bad subsequently, and requiring the whole to be remelted at great expense.

In the yellow metal trials which were made by the new process, the usual charge of about 15 cwt. was tapped into the ordinary mixing furnace-pan and ladled thence into shank ladles, then poured into moulds in the form of plates. Each plate, as soon as sufficiently set, was immediately conducted to the rolls and rolled out, and so on until the whole twelve plates, say, composing the furnace charge, have been rolled right up to the stage ready for the "finishing" rolls, to be ultimately finished into sheets or sheathing; and this work has been executed in about eight or nine minutes, the heat being found to be highly suitable for rolling. It will, therefore, at once be seen that this system offers a very rapid and continuous means of turning out work, the consideration of the time factor alone being of the utmost importance, as well as the fact that the different operations becoming much more continuous, brings about as a result an enormous capability of increasing the output of any mill, and this, too, without augmenting the plant.

One consideration of great value, which might also be submitted in connection with this system, is that the interior of the copper cakes, just after being cast and set, is in a sort of pasty or plastic condition, and whilst being subjected to the pressure of rolling in this state, the metal must coalesce or weld together more perfectly, and so would acquire better physical properties, such as a denser and more homogeneous condition or structure, and, in consequence, might give better results in the mechanical tests for tensile and ductile strains, etc.

In installing a new plant for the more successful carrying out of this system, it would be preferable to have the different sets of "breaking-down" rolls, contained perhaps in one group, handily situated and contiguous to the refinery, so that the cakes or ingots may be rapidly fed from the latter by suitable appliances, and so preventing any undue loss of heat in the transmission of same to the former, although with proper facilities in existing plants the cakes, etc., may be taken great distances without very appreciable loss of heat.

For current orders in the mill the cakes from the refinery would be dealt with as before described; but should it happen that there are no orders, and that the refining furnace must be kept going, and the cakes, plates, or ingots made for stock, then these may be at least "broken down" to certain established widths and lengths by means of the refinery heat, instead of allowing it to be wasted when ladled. They would then be advanced a good deal towards completion, and have had a large amount of work put into them before being allowed to cool. Soundness of the metal would be thus assured, and the material be put on one side to be ultimately "finished" to exact dimensions to suit orders.

The above process, which has been evolved and proved after a long, practical, and intimate experience and knowledge of the trade, and its great importance to copper manufacturers who are also refiners of the metal, as well as to manufacturers of yellow metal and naval brass (two important alloys which are rolled hot), will be readily appreciated when it is estimated that by its adoption, with the accessory apparatus, that at least from 20 to 30 per cent. may be saved in the present cost of manufacturing ordinary strong copper; and that even more than this can be achieved in the case of those products which can be rolled to a finished state without any reheating whatever.

The moulds used for receiving the copper cakes have, as before stated, permanent copper bottoms. These are proved to be better for resisting buckling by heat, produce less pin-holes, as well as possess other advantages, and especially that they are capable of being easily and rapidly stripped.

These moulds, in conjunction with the process, were patented by the late Mr. T. H. Martin, formerly for many years engineer and manager of an important copper works at Swansea.

SUMMARY OF ADVANTAGES DERIVED.

(1) Doing away with reheating for the rolling in the "breaking down" and "drawing-on" stages, thus effecting very important economy in labour, fuel, time, etc.

(2) Doing away with the casting of copper bottoms in the moulds before the cakes are ladled in; therefore obviating the remelting of same, besides increasing the net yield of the refinery.

(3) Avoiding the overheating and burning of plates and sheets in heating furnaces, and therefore also the subsequent remelting of same, as well as preventing the accumulation of grit, dirt, and dust on the surfaces, and the resulting chipping and scraping made necessary in consequence.

(4) Avoiding largely the great waste by oxidation of the surfaces of products through the repeated heating and cooling of same at present practised, resulting in a considerable diminution of the oxide formed.

(5) Doing away with the risk of great waste caused by the "tough pitch" being lost in some of the cakes ladled, and forming part of the refinery furnace charge, and only discovered after the whole has been allowed to get cold, necessitating the remelting of these cakes, to be refined afresh, with all its attendant expense.

(6) Vastly augmenting the yield of the mill, by the work proving much more continuous through doing away with the enforced idleness of the machinery and men, when waiting for the heating of products in heating furnaces.

(7) Ensuring greater soundness and compactness of the metal through working on it whilst the interior is still in a semi-plastic condition, and also producing a great improvement in the appearance of the finished products.

(8) Economising in plant and space by doing away with certain of the heating furnaces, etc.

(*Award*) H. J. MARTIN.

Lining-up Castings.

When lining out a rough casting on surface-table, place it on three hardwood wedges, spacing them that each carries approximately a third of the weight. The job is at once "solid," and there is no "twist" whatever its shape. When adjusting, never drive a wedge in with a hammer: always take the weight off with a pinch-bar or small jack; the wedges will never then get stepped, as they would if driven in against a sharp edge with the weight on. Wedges properly treated will last for years. After the job is roughly set with the scribing-block, see what height the pointer shows on the rule—it may be, say, $12\frac{5}{8}$—then set the point to exact 12 ins. Now go over the job again, setting it this time to the pointer; there is then no difficulty in lining off all faces dead-true, however many there be. Many workmen never seem to grasp this, but will worry over so many $\frac{1}{32}$nds and $\frac{1}{16}$ths when with a little thought they might do the job in half the time and far easier. If it should happen that this rule cannot be followed, as it sometimes does, and that a $\frac{1}{32}$nd crops in, then keep some pieces of thin tin or lagging steel by you of different thicknesses. Place a piece under the foot of the rule until it is raised sufficiently to give the pointer a dead measure; then use that particular piece of packing throughout the job.

THAMIS.

Expanding Mandrels.

In the majority of turning shops, the solid—and at times, clumsy—mandrel, driven into the job by a series of sledge-hammer blows, has been superseded in the modern engineering firms by the expanding and hollow form of sleeve, which requires no driving, and has therefore no tendency to burst the casting into which it fits. In the turning of pulleys, etc., or cutting tooth-wheels having bores of large diameter, the split sleeve or mandrel is used to great advantage, saving the trouble and uncertainty connected with the use of the old-time method of improvised bushes made to suit a solid mandrel, frequently out of truth, or so deeply scored by innumerable cuts as to be almost valueless for accurate work. The type shown at Fig. 1 is usually made of phosphor-bronze, up to a diameter of 6 ins., the openings *O* being cored, leaving a thin wall of metal between each. The larger diameters (Fig. 2) are made in the form of a plate pulley, with ribs *R* radiating from the boss for the purpose of supporting the rim. A number of holes of oval form through the centre-plate serve the two-fold purpose of lightening the casting and assisting the expansion. The castings for these sleeves are first bored and turned to within a fraction of the finished sizes, the bore being left about ·022 smaller, and the outside diameter ·002 larger. The boss is reduced in sectional area between each rib as shown, and divided by a saw cut *S* at each depression, thus forming a series of struts from the centre to the rim. A cut

of about ·10 is made through the rim at *C*, which allows sufficient expansion to grip a bore up to ·125 above the standard size, used in conjunction with the smaller ones, the taper mandrel being inserted in the latter. For heavy work the larger sizes may

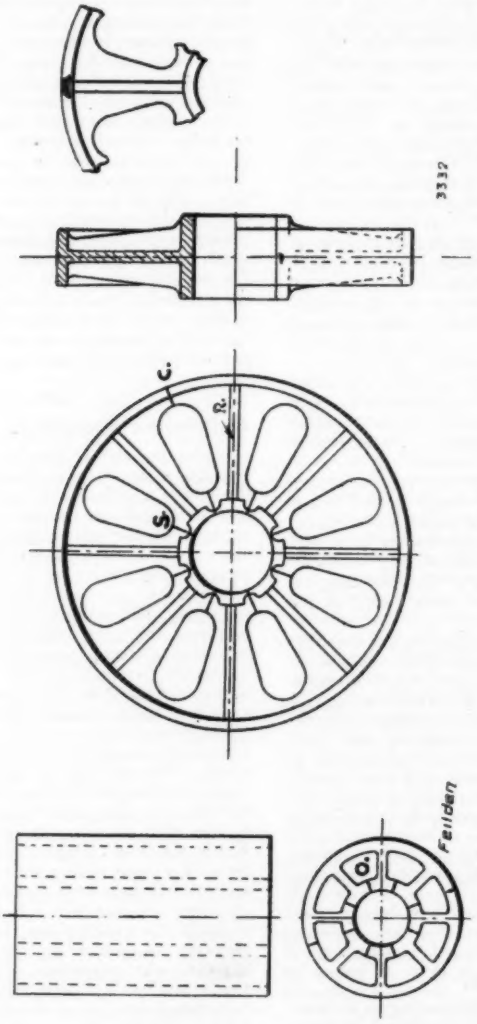


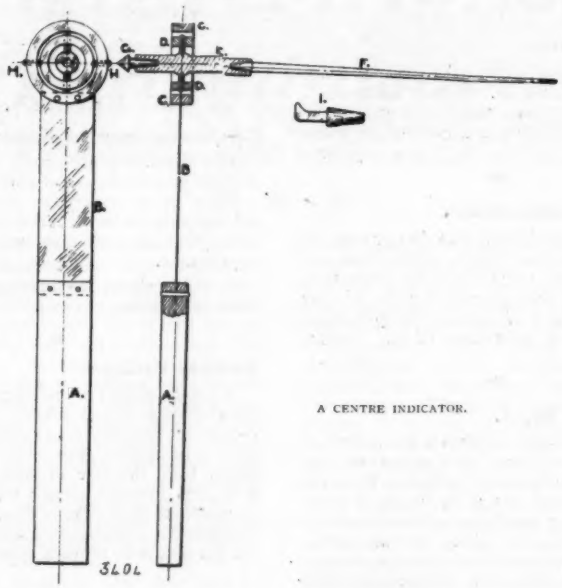
FIG. 3.

FIG. 2. EXPANDING MANDRELS.

FIG. 1.

and resist a fairly heavy cut on either a turning or milling job. The smaller sizes are bored with a taper of 1 in 20, the larger sizes usually parallel; they may then be bored taper, and the mandrel tapered to suit, a nut screwed up to a collar forcing the sleeve up. Mandrels of this form are valuable accessories to both turning and

wheel cutting, and a variation in size—beyond the limit of expansion—to suit fractional or metric measurements, may be obtained by the use of steel strips of the requisite thickness, milled to fit the dovetailed slots cut on the periphery of the sleeve, and opposite the arms, as shown in block section on the right of Fig. 2. WHEEL-CUTTER.



A CENTRE INDICATOR.

A Centre Indicator.

The tool illustrated above, and described as follows, is a centre indicator. By its aid a piece of work can be set true on the lathe face-plate within ·001 in., and it is easier to use than a scriber fixed in the tool-box in the usual manner. *A* is the stock, of iron case-hardened, or mild steel; *B* is a flat spring fastened by rivets into stock and ring *C*. Ring *C* is drilled and tapped for two pointed screws *H*. Ring *D* is drilled and tapped for two similar screws and is countersunk to receive points of screws in outer ring *C*. The spindle *E* is countersunk to receive points in ring *D*, the whole forming a universal joint, *E* being free to move in all directions. *E* has a taper hole in each end, one for centre *G*, and the other for pointer *F*, made of wood about a foot long. To use the indicator, fasten the work (which has been previously marked out) on the face-plate approximately central. Fasten stock *A* in tool-box, with centre of *E* parallel to lathe centres; put *G* in centre of work, and revolve the face-plate. If the job is central, the end of pointer *F* will be motionless; but if the work is the least bit out, the pointer will describe a circle, and the work must be adjusted until the pointer ceases to move. If, in place of centre *G*, *I* is inserted, the indicator may be used for the testing of bored holes.

ARTHUR SPEIGHT.

WORKSHOP QUERIES AND ANSWERS.

WILL some of our readers kindly answer the following?

Tube Drawing.

I have an aluminium tube 12 ins. long, ½ in. diameter, ·05 in. thick. How can I reduce it to a gradual taper of, say, ¼ in. at the other end, keeping it a uniform thickness throughout? J. B.

Building Commutator.

Which is considered the better way to build a commutator: on its sleeve cold, and heat it afterwards; or to heat the sleeve first, before placing the commutator on it? As there is a diversity of opinion on this point, I should like to have some of our readers' opinions on it. E. C.

Iron *versus* Steel.

I am at present employed by a firm of heavy-engine builders (slow speed) of high repute, but much to my surprise they use iron, to the almost entire exclusion of steel, for the following details:—Large connecting-rods and straps for ditto, cranks, crank-shafts, and even studs for cylinder covers; which seems somewhat contrary to high-class practice, as far as my experience goes. Can any reader answer, if iron possesses sufficient advantages to warrant its use in preference to mild steel for the above important steam-engine details? W. D.

Polish on Turned Work.

What is the cause of the polished appearance of wrought iron and steel if soapsuds are used as a lubricant when turning the same?

Hardening Change.

What change takes place in the nature of steel when hardened for cutting purposes? H. P.

REPLIES.

Circumference of Boiler Shell.

(*a*) Length of plate equals inside diameter of shell plus thickness of plate by 3·1416.

(*b*) It is necessary to bevel the plate on opposite sides at each end to form a close joint, and for good workmanship and appearance.

(*c*) Extra allowance for lap generally equals *twice the thickness* of plate. T. S.

Cutting Chasers.

A good method of cutting chasers for adjustable dies—if not already fixed to a lathe—is to set the box on a central position on the lathe-saddle, and with a hob slightly larger than the size of dies take three or four cuts through them; this gives a slight clearance to back edge of dies. When cutting commences, a slight pressure should be kept on the saddle to prevent straining the hob. GAUGER.

Tracing Tools.

Each workman makes out a note stating the tool he requires, together with his name and date of month. These the storekeeper places on a file, the notes being entered weekly in a special book kept for that purpose, and which contains a supply and return column, a similar note being handed in on returning the tool. E. C.

[This scarcely simplifies the check system. —ED.]

Engineering Notes From all Sources

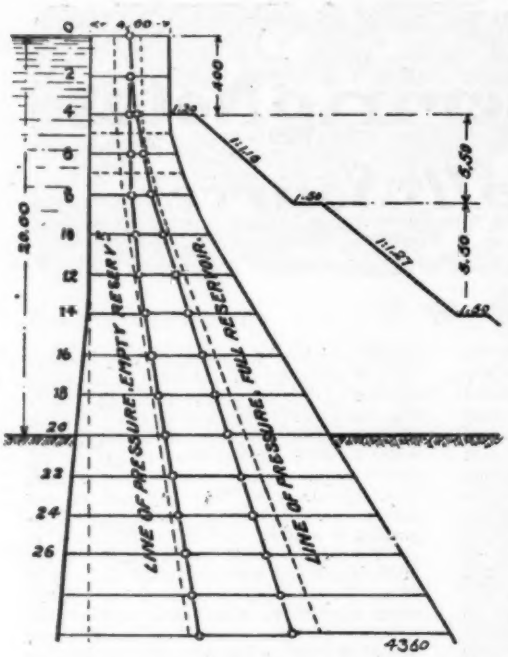
❀ ❀ ❀

Deterioration of Steel.

THE tenacity of steel may be ample, its elastic limit high, and its ductility satisfactory as measured by elongation and reduction of area. It may even stand the severe test of bending double when cold without any sign of rupture. Yet it may, without warning, snap like glass under the influence of stresses far below its elastic limit. On examination, it is evident that it has deteriorated from long use; the assumption is frequently made that the steel has become crystalline from the effects of vibration, and it is generally agreed that no blame can be attached to anyone. It may be assumed for the present that steel really does deteriorate and become fragile under the action of vibration or shock, if only to avoid the necessity of explaining why fracture takes place, there is little evidence on which such an assumption could be based. Micrographic investigation has made it almost certain that injury may be inflicted on certain steels by stresses which do not cause perpetual permanent deformation. When steel has been damaged in this way, fracture appears to be usually preceded by the appearance of numberless microscopic flaws. In certain cases these micro-flaws will be found mainly in intergranular material, and, as Arnold has pointed out, any cellular structure in which the cell walls are composed of different material from that within them is dangerous, owing to the fact that frequently the co-efficient of contraction of the cell contents is not identical with that of the cell walls, so that the steel, before it is used, may be already far on the way to disintegration. In other cases, however, the fracture occurs mainly along cleavage planes in crystals, where the intergranular matter, if there is any, remains uninjured. Here the microscope often reveals the presence of numbers of minute flaws in the metal near the surface of the fracture. A few are of sufficient magnitude to be called "incipient" fractures, and they indicate what is probably the real effect of vibratory stresses acting on steel, essentially fragile and unsuitable to withstand shocks. Fragile steel deteriorates rapidly, but in tough steel, really suitable for the work it has to do, deterioration would probably be almost imperceptible, even with the aid of the microscope. Testing by impact, like micrography, is still in its infancy, but there is great hope that it will yield valuable results in distinguishing between tough and fragile steel. To sum up, the work of the last few years appears to point these conclusions: (1) that the deterioration of steel under vibration is less potent as a cause of fracture than the use of faulty material; (2) that any deterioration that may occur is not likely to be mainly due to re-crystallisation in the cold during use, but to the gradual cleavage and breaking up of the crystals already present, with the accompanying production of minute flaws; and (3) that the varieties of steel likely to undergo rapid deterioration under vibratory stresses, although they cannot be distinguished by the old methods of testing, may ultimately be recognised by the use of the new tests, which have not yet been generally accepted.—*The Engineer*, Sept. 19, 1902.

The Lauchensee Dam.

A NEW masonry dam in the upper valley of the Lauch, one of four similar works designed to increase the low-water flow in the streams of the Vosges, has recently been completed by the German Government. The dam rests everywhere on sound graywacke, with the seams and joints cleaned out and filled with rich concrete. The structure is curved in plan to a radius of 2,950 ft., and its cross-section is shown in the accompanying illustration. The line of pressure, with both full and empty reservoir, is within the middle



THE LAUCHENSEE DAM: STRESS DIAGRAM. DIMENSIONS IN METRES.

third, and at the overflow section at each end the thickness was increased 20 ins. Observations on the elastic behaviour of the other Vosges dams indicate that water pressure exerted a much smaller influence than the expansion due to fluctuation of temperature, which in these valleys amounts to about 100 degs. Fahr. Under these fluctuations movement of the masonry can readily be detected, and, although insignificant, it is undesirable and should be reduced to a minimum. For this purpose the down-stream face of the Lauchensee dam has been covered with earth, which is expected to prevent much of the temperature motion. The reservoir has a capacity of 204,000,000 gals. at the usual flow line, 3·28 ft. below the crest. The waste-weirs have been given unusually large dimensions, according to German practice. Water is drawn through two openings into a culvert in the dam, which discharges into a paved channel leading to the river; and the lower end of the culvert, outside the dam, is widened, so as to form a chamber where the velocity of the stream is checked. The dam was built of "graywacke" rubble, the stone for the culvert facing was granite, and the coping, parapet and arches over the waste-weirs are concrete. Trass-lime mortar was adopted for setting the masonry, as the conditions made it preferable to cement mortar. Since the mortar was a purely hydraulic material, it was desirable to expose the finished masonry to water as soon as possible. For this purpose a ditch was dug outside the catchment area, intercepting and conveying the water of several springs and brooks to the reservoir, the level of which, during the winters of 1892 and 1893, was always kept within a short distance of the top of the work. Under these conditions the mortar hardened excellently during the two years in question. The embankment on the down-stream face of the dam was not put in place until after the reservoir had remained filled for four years. In this way it was definitely settled that the masonry was without defects. The joints on the down-stream face were then scraped out and pointed with rich cement mortar. The earth embankment was then placed in horizontal layers and its surface covered with a stone pavement. The dam contains 37,400 cubic yards of masonry, of which 65 per cent. is stone and 35 per cent. mortar, the total cost of the reservoir being 243,750 dols. The work was carried out by the Government, Mr. Fecht being the chief engineer.—*Engineering Record*, August 30th, 1902.

Newcastle New Railway Bridge.

EVERYONE who has travelled into Scotland by the North Eastern Railway, must have observed the awkward manner in which the train had to get into and out of the Central Station at Newcastle. The train, it will be remembered, entered moving in one direction, and left moving in the opposite direction. This inconvenient arrangement is due to the fact that the High Level Bridge, which carries the line across the Tyne, is further down the river than the station. Hence the railway, which runs eastward on the south of the river, runs westward after crossing it, and enters the station from its north-east end. The lines running northward leave by the same end, and the result is the inconvenient system of changing ends which is necessitated. In order to get over this difficulty, the North Eastern Railway has had under consideration for many years the construction of a new bridge further

up the river, that would permit of the train entering the station by the south-west, and leaving, moving in the same direction, by the north-east, and it has been at length decided to build it. The site which has been chosen is close to the lately reconstructed Redheugh Bridge. A moderate curve will carry the line on to the bridge, and a reverse curve at the other end will bring it on to the Carlisle branch, and so into the station. The new work has more than the mere convenience to recommend it, as it will undoubtedly save a few minutes by the shortening of a troublesome bit of the road. The bridge is to be a straightforward steel structure, carried upon three piers, with stone approaches at both ends. It will carry four lines of railway. The work was commenced in May last, and the cost will be about £450,000. The contractors are the Cleveland Bridge and Engineering Company, and it is hoped that the bridge will be ready for traffic by October, 1904.—*The Engineer*, September 5th, 1902.

The American Engineer in England.

In a recent paper Mr. W. G. Sloan, of Chicago, relates his experience in connection with the erection and equipment of the Westinghouse Works, Manchester. English builders said it would take five years to erect the works; but as this did not satisfy the Americans interested in the concern, they looked naturally to the United States for help. Therefore the firm of James Stewart & Co., of St. Louis and Pittsburg, were asked to "take hold of the work and push it through," after having offered to complete in fifteen months. Immediately upon the arrival in Manchester of Mr. Stewart and his staff it was evident that a complete reorganisation was necessary, in the making of which much opposition had to be met; but Mr. Stewart was determined to do the work by American methods, and not many weeks passed before things were running to his satisfaction. The clerk of works and a dozen assistants, scattered all over the site in little offices, were moved into a large office, and told that instead of coming on the job at nine and leaving at five they must "be on hand" when work started and stay till it stopped. Half of these clerks then resigned, saying "A man cannot be a gentleman and work under the American administration." Trouble was also experienced with the men's breakfast time, which wasted one of the best hours of the day, the men gathering in groups, lighting fires and making tea in little pots; it was also a trouble to get them into the swing of work again. Matters were helped to a great extent by the building of a furnace to provide hot water for the men, it being made a rule that no other fires should be lighted. Breakfast time as an institution was discouraged in every way, and at last all the trades but the bricklayers agreed to give it up. Mr. Sloan then explains why an American builder, in the face of the fact that he was in a strange country, where labour was more tied down by unions than in the United States, and where he might be hindered by the jealousies of men in the same profession, was able to do this work quicker than these same men. English bricklayers seldom lay more than 400 to 500 bricks per man daily, but shortly after the Americans took up the contract the bricklayers were persuaded to lay 900, and later 1,900 bricks per man daily, while the record per man per day was 2,100 bricks. The mortar used was thinner than that mixed in English practice, saving time and labour, and the best men were got hold of by paying more than the Union rate of wages. England is said by the author to be resting on her laurels—the tools and appliances in manufacturing establishments are described as those which were used and discarded in America twenty-five years ago. The English employer is prone to lay the blame for England's decline in trade on the workman, but Mr. Stewart proved what can be done with the English workman under proper management. Generally speaking, says the author, the trouble is with the managers and not with the men. On the Manchester work the foremen all turned into the office a daily report showing the work done, and if this was not satisfactory, Mr. Stewart took steps to make it so in future. This kept everyone up to the mark, and operations were also pushed forward by the most approved appliances, in the shape of mortar mixers, concrete mixers, brick hoists, painting machines, etc. The author concludes by saying there is a future for the American who can go to England taking American methods with him, and he is bound to "win out" in the end. The Americanisation of England, to his mind, is bound to come at no distant date.—*Journal of the Western Society of Engineers, Chicago*, August, 1902.

Harbour Improvements at Capetown.

A comprehensive scheme of harbour improvement for Capetown, prepared by Mr. W. C. Methven, M.Inst.C.E., and Mr. H. H. Hammersley Heenan, M.Inst.C.E., engineer and general manager to the Harbour Board, is now under the consideration of Messrs. Coode, Son & Matthews, of Westminster. The contemplated im-

provements are momentous for the future prosperity of Capetown, and if they are sanctioned by the Cape Parliament the port will at last be placed in a position to cater for all future demands of commerce and traffic. The extent of the new departures contemplated may be gauged by the fact that the proposed works will involve an expenditure of over three and a half millions sterling. This will be a trifle for the finances of the colony, but its investment will be well repaid. In detail the projected works are the following :—

I. The extension of the South Pier elbow southward by a pier 1,200 ft. long, situated on the harbour side, having a depth of water of over 40 ft. This pier will be fully equipped with sheds, electric cranes, railways, roads, lighting service, water-supply system, surface drainage, etc.—the estimated cost being £372,000.

II. The widening of the South Arm by the construction of a quay wall 2,200 ft. long, having a depth of water varying from 20 ft. at the inner end to over 40 ft at the outer end, fully equipped with sheds, electric cranes, railways, etc., as in the proposed extension to the South Pier, the estimated cost being £321,000.

III. Building of a quay wall with reclamation works from the foot of South Pier, southward to Adderley Street Pier, the wall having a length of 3,300 ft. and a depth of water at low water of 20 ft., the quay to be equipped with sheds and appliances similar to the South Pier and South Arm, the cost of the whole works being estimated at £525,000.

IV. Construction of a pier at the foot of Adderley Street, 2,675 ft. long, fully equipped with sheds, cranes, etc., as the forenamed works, the total estimated cost being set at £762,000.

V. Extension of quay wall or reclamation works south of proposed Adderley Street Pier, including rubble mounds, the wall being 1,350 ft. long, with about 20 ft. depth of water at low water, at an estimated cost of £263,757.

VI. Construction of a concrete mole 7,000 ft. out from Craig's Battery, having a depth of 9 ft. above low water and an average length of 40 ft., at an estimated cost of £756,000.

VII. Construction of storm water drains at a cost of £85,000.

VIII. Construction of a temporary timber jetty on the foreshore south of Adderley Pier at a cost of £35,000.

IX. Extension of the breakwater by 1,000 ft. in block concrete at a cost of £325,000.

X. Provision of two 1,000-ton capacity 8½-knot dredgers, at a cost of £80,000 ; four stationary reclamation dredgers, of a capacity of 50 tons per hour to a maximum distance of 2,000 ft., £32,000 ; and piping and floats, £5,000—or a total estimated cost of £117,000.

The grand total of the proposed expenditure is thus £3,561,757. The scale of the reclamation, pier, quay, and other projected works will far exceed those needed for immediate requirements ; and while the large scheme contemplated will necessarily take years to complete, portions of the work and temporary supplementary works will be undertaken forthwith to relieve some of the most pressing needs.—*British and South African Gazette*, September, 1902.

The Compression of Steel by "Wire-Drawing."

A PAPER by Mr. A. Harmet, of St. Etienne, relates to the compression of steel in the ingot mould, the object of the author being to point out a new method of producing compressed steel. In the ordinary way the nature of steel may be changed in the mould owing to various causes. When the metal begins to cool it shrinks so as to come away from the walls of the mould. There is a solid steel shell, which surrounds a mass of liquid metal. As the latter cools, it shrinks, and little by little during cooling the fluid steel becomes plastic and attaches itself progressively to the shell, leaving a hollow corresponding to the shrinkage. The still liquid metal flows down from the surface to fill these hollows, and, as the centre cools last, there is thus left a hollow space extending along the axis of the upper part of the ingot. The lower central part of the ingot also has porosities and tiny cracks, and fissures permeating the whole mass can be detected by the microscope. When the lower part of the ingot is solidified throughout its whole thickness, and as soon as the descent of the upper layers of liquid metal is interrupted, the shrinkage, proceeding as the cooling continues, sets up within the metal injurious stresses. Moreover the steel in solidifying forms into crystals which have little cohesion between themselves, and, when stresses are set up, due to contraction within the metal, these meet with but low resistance, and cracking occurs easily. The metalloids which enter into the composition of the steel have a tendency to separate from the iron by liquation. The carbon being the most mobile is attracted towards the fluid parts, finally concentrating where solidification last takes place—that is, at the head of the ingot. The ingot as cast may therefore be useless, and recourse has to be had to mechanical treat-

ment, by rolling or forging, to correct defects, the cracks and fissures rewelded, the stresses relieved, and the crystals reduced to a fine state. The upper end is cropped to waste. In order to overcome these defects in steel which may be, as it comes from the furnace, of good composition, the author effects compression on the steel whilst it is in the mould by "wire-drawing." This term being adopted because the pressure applied at the base causes the metal to rise in the conical mould as though being forced through a draw-plate, as wire is drawn. The author claims that his system possesses certain advantages over the older methods. He states that, in spite of the great force of the pressure applied, the effect only extends to the exterior of the ingot, which, on cooling, rapidly forms a crust with the rigidity of a column and thus arrests the force applied and protects the central part. The method may answer for hollow pieces, but is ineffective for solid bodies such as armour-plates. In the author's system pressure is applied by means of an hydraulic press to the bottom of the ingot whilst it is liquid in the mould. It should be stated that the ordinary ingot mould is open at the top and the bottom, and that it tapers towards the top, so that the upper diameter is less than that of the lower part. By applying pressure from below, the ingot, which has shrunk on cooling, is thrust upwards into the smaller part of the conical mould. The cooled shell thus presses on the central part, and the hollows due to shrinkage are not free to form. By hastening the solidification in this way the tendency to coarse crystallization is counteracted and the tendency of the carbon to accumulate is lessened. The paper states that with this method production is increased 25 per cent., and in the discussion which followed Mr. Beardmore of Glasgow said that after full investigation he had ordered a press for use in the solidification of armour-plate ingots, believing the result would justify the large outlay involved. —*Proc. Iron & Steel Institute*, Sept. 1902.

Coast Protection.

IN the course of a comprehensive paper on "The Protection and Improvement of Foreshores by the Utilisation of Tidal and Wave Action," Mr. R. G. Allanson-Winn, M.Inst.C.E.I., refers to the "Case" system of groyning as one which may be relied upon to collect and retain travelling beach material in such a way as to protect the toes of sea-walls. The author says that the inventor, the late Mr. Edward Case, took a long step in advance when he promulgated his theory that every shore has its own inclined surface of repose, and that that surface could be brought about by accumulations mainly derived from the travelling material between mean sea-level and low-water mark. If, he argued, a shore can be made to once acquire this surface, from which there is the minimum chance of alteration through the action of waves and currents, sea-walls, properly so called, will not be so necessary as formerly for the protection of esplanades, seaside roads, etc. If a good "full" of beach can be secured, a comparatively light retaining-wall will be sufficient, for the beach itself can be relied upon as a protection for the foundations, and there will be the satisfaction of having saved heavy expenses in the costly concrete structures which would otherwise have been considered necessary. Being quite convinced of the soundness of his theory, Mr. Case designed groynes of a form which is simple, inexpensive, and capable of rapid construction. These are low groynes, and are entirely of timber. They were first applied at Dymchurch, which must be regarded as the cradle and home of the "Case" system. They commence about sea-level, and run down to low-water mark. Among the advantages claimed for those groynes may be named the following:—They are economical as regards time, labour, and cost of materials. No plant or skilled labour is required, though experience is needed in the adjustment of the planking; all the timber used is of the same scantling, manipulation is easy, and the cost of repairs very trifling. In action these groynes rely on the multiplication of small results. There is nothing sudden, and the services of that restless, never-tiring workman, the sea, are enlisted, while the destructive forces of the elements are converted into constructive forces. —*Proceedings American Society of Civil Engineers*, August, 1902.

Effect of Variations in the Constituents of Cast Iron.

A PAPER read by Mr. W. G. Scott at a meeting of the International Association for Testing Materials, contains a good deal of useful information as to the influence of the metalloids on cast-iron, and the observations of the writer are made from a practical rather than from a theoretical point of view. His conclusions, expressed very briefly, are as follows: Silicon softens iron, imparts fluidity, decreases shrinkage, opens the grain, promotes the formation of graphitic carbon, and reduces strength. Sulphur makes the iron hard, increases shrinkage, promotes chill, causes the iron to congeal quickly, and gives rise to blow-holes, shrinkage cracks, dirty

iron, etc. Phosphorus lowers the melting point of iron, imparts fluidity, decreases shrinkage, weakens the iron, and makes it "cold short" or brittle under impact. Manganese above a certain point hardens the iron, increases shrinkage and chill, reduces deflection, and changes graphitic carbon to the combined.

Within certain limits, it softens iron by neutralising the effect of sulphur, decreases shrinkage and chill, increases strength, and eliminates blow holes. Combined carbon closes the grain, increases shrinkage and chill, and increases strength. Graphitic carbon weakens the iron, decreases shrinkage and chill, and makes the iron soft.

The article concludes with some description of "special mixtures" for grey iron castings. For the ammonia cylinders of ice-making machines the following mixture is recommended as producing a strong, hard and close-grained iron.

Silicon—between 1·20 and 1·60 per cent. where castings are allowed to cool slowly, or are annealed. If not annealed, silicon should be between 1·60 and 1·90 per cent. Sulphur should not exceed 0·095 per cent. on account of hardness, but with a high total carbon it may run up to 0·150 per cent. without detriment, although with high sulphur there is always a chance of hard iron and excessive shrinkage, especially in low silicon mixtures. Phosphorus should be kept below 0·70 per cent., and if great strength is wanted it should be much lower, say 0·40. Manganese should not exceed 0·60 per cent., except in case of high sulphur, when it may rise to 0·80 per cent.

Medium iron for engine cylinders, gears, etc., may be made on the following formula: Silicon, 1·40 to 2·00 per cent. 1·50 per cent. silicon gives the best results for gears, and 1·60 per cent. for steam cylinders.

If the castings have thin parts and have to be shaken out of the sand quite soon the silicon should be raised ten or twenty points. Sulphur is best kept below 0·085, but if the manganese be high (0·60 or 0·70) the sulphur may run up to 0·100 per cent. The lower the sulphur the softer the iron. Phosphorus should not exceed 0·70 per cent. Manganese should be between 0·30 and 0·70 per cent.

Soft iron for pulleys, small castings, etc. Silicon should be between 2·20 and 2·80 per cent. The ideal mixture is 2·40 per cent. of silicon. Sulphur should not exceed 0·085 per cent. If above 0·095 there is liable to be trouble with hard iron and shrinkage. Phosphorus may run up to 0·95 per cent. in small thin work, but if strength is wanted it will be advisable to keep it down below 0·70. Manganese may be between 0·30 and 0·70.

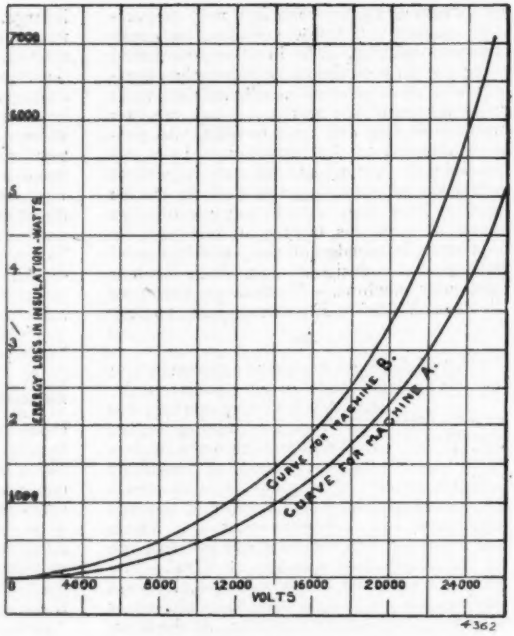
For obtaining specified results the following points may be considered, any one of which will produce the desired effect:

To raise the strength—reduce graphite, phosphorus, and silicon; increase manganese and combined carbon. To reduce shrinkage—increase silicon, graphitic carbon, and phosphorus; reduce sulphur. To prevent blow-holes—reduce sulphur; increase manganese. To prevent kish—reduce graphite by increasing scrap, or raise manganese.—*The Foundry*, Sept. 1902.

Energy Loss in Insulating Materials.

THE object of a paper, by Mr. C. E. Skinner, presented at the annual convention of the American Institute of Electrical Engineers, is to discuss the effects of energy loss in commercial insulating materials when subjected to high potential stress, and to give some characteristic results obtained from tests on various materials used in manufacture. The specific tests given in the paper are intended to show characteristic and not quantitative results; and while the results are true for high potential stresses, they are of little commercial importance in ordinary low potential apparatus. They are of the greatest importance in very high potential working, and have a direct bearing on the question of long-continued tests of the dialectric strength of finished apparatus at very high voltages. The results of a series of tests for variation of temperature due to variation of stress are shown in diagrammatic form. Three of the curves relate to a sample of untreated material, which was quite porous and capable of absorbing moisture from the air. In this test the material was well ventilated, so that any moisture could be quickly dissipated. One curve shows the effect of moisture, the temperature rising rapidly to a maximum, then falling, and at last becoming stationary; a second shows the effect on the same material after thorough drying; a third shows the increased temperature due to a slight increase in the stress; and a fourth shows the rise in temperature in treated material when poorly ventilated, and the test continued until breakdown resulted. Breakdown in this particular test occurred at a point about 4 secs. from the thermo-junction when the measured temperature reached 135 degs. Cent. The temperature of the surrounding air in this test was kept at 80 degs. Cent. This curve shows the tendency of the temperature to become constant, but at a point slightly over 100 degs. Cent. the loss becomes so great that the heat cannot be dissipated as fast as generated; hence the change in direction of the curve

and final breakdown. In numerous tests the material was found to be badly charred on the interior without breakdown having resulted. The curves shown are characteristic, and are of the same form as many others that have been taken. Variation of loss due to variation of temperature is graphically shown on another diagram, the curves having been taken by means of a static watt-meter on a sample of material known to be in the very best condition as regards moisture, etc. This general form of curve has been found to hold for all materials tested, although the rate of change of the loss and the amount of the loss per unit volume may be very different for different materials, and even for the same sample of material under different conditions. These curves indicate that the rate of increase of loss is greater at high than at low temperatures, thus giving the reason for the greater rise in temperature with a given stress when the initial temperature is high than when it is low. Other tests have shown that losses as great as 5 watts per cubic inch have been measured before serious injury resulted from charring; and it follows that a long-continued test at high stress may seriously injure the insulation of a piece of apparatus without this being made apparent by the test. This is often spoken of as "straining the insulation." It is probable that this straining is always due to charring. The same diagram also shows variation of loss due to variation of frequency, and it should be noted that the rate of variation is approximately in proportion to the frequency at the lower temperatures, but follows a different law at the higher temperatures. Some measurements recently made of the energy loss in the armature insulation of the 5,000-kilowatt alternators built by the Westinghouse Electric and Manufacturing Company for the Manhattan Railway Company should prove interesting in this connection. These tests were made to check some of the results obtained on a smaller scale and to give some of the conditions existing when very high potential tests are made on large high-voltage apparatus. The losses were measured by a static watt-meter, as before. Measurements were made at about 5,000, 10,000, 15,000, 20,000, and 25,000 volts, and they are indicated for the two machines tested on the diagram reproduced. The amount of insulating material under stress in these tests was approximately 19,500 cub. ins., this giving a maximum measured loss of 0·35 watts per cubic inch at 25,000 volts. At a stress of 11,000 volts between the windings and the frame the loss measured was less than 1 kilowatt total for the machine. The loss in the insulation during normal operation of the machine will be much less than this, as the maximum stress to ground when circuits are statically balanced will be approximately 6,400 volts at the lead end of the winding and 0 at the neutral point. As the loss increases approximately as the square of the voltage, the total loss due to normal operation will be only one-third of the loss at a stress of 6,400 volts applied between the windings and the frame. The total loss, therefore, under normal conditions of operation and at the normal temperature at which the machine will run will be less than $\frac{1}{2}$ kilowatt, which is entirely negligible, both as regards its effect on the efficiency of the machine and on the rise in temperature. On the other hand, it will be seen that the loss



ENERGY LOSS IN INSULATING MATERIALS.

at a stress of 25,000 volts is a very measurable quantity, but not sufficient to cause injurious heating, even in a long-continued test; the form of the curve shows that heating will increase very rapidly as the stress is increased above this point, and the loss would then begin to cause heating, and possibly damage to the insulation. It is not possible, the author says, to state in general terms the safe limiting stress which can be applied in a time test to a piece of high potential apparatus, but measurements of the loss and a knowledge of the materials used will give the designer some idea for any particular machine.—*Proceedings American Institute Electrical Engineers*, June, 1902.

Electrically-Operated Canals.

One of the most successful experiments on electric haulage made in Europe is on the Charleroi Canal, serving the Charleroi coal-mining region in Belgium, with more or less success. Prevailing conditions limit the speed and economy, but these could be greatly improved with a new and modern equipment and a better waterway. There are at present two central power stations, one at Oisquereq, and another at Roux. The former is equipped with three 125 h.p. Corliss engines, each driving a polyphase alternator supplying current at 6,000 volts. At the Roux station the generator sets have a capacity of 325 h.p. each, supplying current for lighting and industrial purposes, as well as for the canal apparatus. Sub-stations are located at points about three miles apart, each containing a step-down transformer which lowers the potential to 600 volts. Electric automobiles of about 5 h.p. are used to draw canal boats in the same manner as horses. They work over sections of various lengths, and when one automobile meets another going in the opposite direction, tow-lines are exchanged and each "tracteur" returns with the boat it has met. The canal boats have a capacity of 70 tons, with a draught of only 3 ft., and they are hampered by the shallowness of the water, which is only about 3½ ft. deep. The banks of the canal are very narrow and in very poor condition; indeed, so bad are the paths in some parts that electric tug-boats have to be employed, receiving current from the bank through an arrangement somewhat similar to that adopted in overhead tramway systems, but in this case the device is such that the boat can travel at a distance of fifty feet from the supply cable, and it is free to manœuvre as an ordinary tug-boat. Owing to the narrow path, and heavy and irregular loads due to the small depth of water, the speed is low and the amount of energy required is large. The necessary current per boat-mile is about 6·5 k.w. hours, while the mean traction pull is 360 lbs. Even with these disadvantageous conditions, the speed of towing has been increased from 1¼ miles an hour with horses, to 2½ or 3 miles an hour, without additional cost per mile ton. The total annual traffic amounts to more than 500,000 tons. This electrical haulage system was designed and constructed under the direction of Mr. Leon Grand, the consulting engineer to the Compagnie Générale de Traction Electrique sur les Voies Navigables. —*Marine Engineering*, Sept. 1902.

Storage Batteries.

In a paper contributed to the Civil Engineers Club, of Cleveland (U.S.A), the belief is expressed that the storage battery will in time be regarded as an essential adjunct to the electrical equipment of every mill and factory. The author starts with the definition of a storage battery as a reservoir of energy, and argues that it is as necessary in electrical work as the gasometer in a gas-plant, or the accumulator in hydraulic plant. After describing the construction and action of batteries, the author discusses the various methods of regulation. Where a battery is to be used under conditions of work giving "peaks" of considerable duration in the battery diagram, or to carry night load when the plant is shut down, the "end-cell," "counter-cell," or rheostat connections are generally adopted. A battery can be slowly charged all day when a little surplus power exists, and in the evening it will assist the generator in carrying the load. Such employment of a battery is advocated where it is desired to increase the capacity of a plant already taxed to its full capacity during "peak" loads. The engine may be kept approximately fully loaded all the time by charging when the load is light and discharging when heavy. The end-cell switches can be operated to throw cells in or out in such numbers as to make the battery carry any quantity of the load which the engineer may desire. Similar regulation may be obtained in small installations by the use of a rheostat, thereby saving the expense of the end-cell connections, but this method is less economical, owing to C^2R losses in the resistance. Counter-cells are employed where exceedingly close regulation is required. They respond very readily to changes of current, maintaining very constant voltage at the lamps, and giving the entire system an elasticity not otherwise attainable. Owing to the increased number of cells, however, they are rarely installed in very large battery

plants. The paper next deals with a class of work where highly fluctuating loads have to be encountered, causing various unsatisfactory disturbances. In cases of this sort, a scheme is recommended in which all the lights and other constant loads are placed across the generator bus, and all fluctuating motors on a separate bus. The battery is across the variable load bus, and a constant-current booster supplies current from the generator bus. In this manner the average current of the variable load is supplied as a constant load, the battery taking the average current to charge in the intervals when there is little or no call for current, and discharging heavily when the momentary peaks come on, thus adding to the average current supplied by the booster, enough current to meet demands. This system requires a relatively small regulating battery, and greatly reduces the amount of generating machinery needed. It maintains a constant load on the generators, insures a steady light and steady high load factor, with excellent economy of operation. Whenever the fluctuating load ceases, the two sets of busses may be tied together, cutting out the constant current booster, and the battery can be used in the usual manner. When the average current varies greatly, the author suggests the use of a differential or compound booster in series with the battery, the booster charging or discharging the battery according to the requirements of the external load. In this way, the author says, the output of the machinery can be regulated to within ten per cent. of any given amount.—*Journal of the Association Engineering Societies*, July, 1902.

The Magnetic Properties of Iron and Steel at Low Temperatures.

An article by Mr. C. C. Trowbridge gives a brief account of investigations relating to the effect of low temperatures on the magnetic properties of iron and steel. After a statement as to the temperature of liquid air, and the peculiar properties of liquid oxygen, a description follows of the experiments made by Professors Dewar and J. A. Fleming in this country, Professor T. Claud in France, and by others, including the writer. The results of these investigations, while not entirely conclusive, seem to indicate the following facts:—(1) That liquid oxygen has a considerably higher magnetic permeability than other liquids, but far lower than that of the so-called non-magnetic iron alloys; and that, at least in the case of liquids, magnetic susceptibility is a function of the state of aggregation rather than merely a property of the molecule, *per se*. (2.) That the magnetic moment of a permanent steel magnet is independent of the temperature at which magnetisation takes place, and that a change of temperature in either direction after magnetisation will cause a permanent loss in the magnetic strength of the magnet, the amount of this loss depending upon the composition and the hardness of the steel and the number of degrees change in temperature to which the bar is subjected. It is also evident that steel magnetised at liquid air temperature in a strong field becomes saturated magnetically almost instantly, as it does at normal temperatures. That when a magnet has been subjected to a series of temperatures, has lost some of its initial magnetic strength, and has reached a permanent condition, that cooling (to liquid air temperature) causes an increase in the magnetic moment, and that heating diminishes the magnetic moment. That steels containing 19 to 29 per cent. of nickel behave in an exceptional manner, for the effect of cooling them to -185 degs. is to temporarily decrease the magnetic moment after the permanent magnetic condition has been reached. (3.) That the magnetic permeability of annealed soft iron is less at liquid air temperatures than it is at normal temperatures, but if the iron is hardened then the magnetic permeability becomes greater at the low temperature. Highly tempered steels, however, appear to behave like annealed soft iron, the low temperature having the effect of diminishing the magnetic permeability. (4.) Two separate investigations have thus far been made on the effect of liquid air temperatures on the hysteresis loss in iron for high induction densities. The results obtained are in agreement, and indicate that the hysteresis loss is the same at normal and very low temperatures. *Electrical World and Engineer*, Aug. 30th, 1902.

The Heating of Toothed-Core Armatures.

Armatures of the toothed-core type in dynamos and continuous-current motors sometimes heat more than might be expected from their size and output. The reason appears to be somewhat obscure, and overheating of the kind probably came as a surprise to makers of such machines. Recognising how important is the question of armature heating, Mr. F.W. Davies points out in what way accompanying losses may be influenced by the general design of a machine. Observations made by the writer on various machines having toothed-core armatures which heated unduly, have demonstrated the following facts: Firstly, that such over-heating is more marked in

machines of the multipolar than the bipolar type, especially in the smaller sizes; and secondly, that the temperature rise is not at all proportional to the load on the machine, but is more marked at light load than at full load. The principal sources of loss of energy (and, consequently, of heating) in a continuous-current armature are the hysteresis loss and the loss due to eddy-currents in the core stampings. Judging by the fact that cases of heating usually occur in toothed cores, the writer comes to the conclusion that the teeth are probably the seat of the trouble. Armature teeth are frequently made narrow with the idea of minimising the armature reaction, and, consequently, the sparking at the brushes. This practice increases hysteresis and eddy-current losses, thus lowering the efficiency of the machine, and it is suggested that the armature reaction may be reduced equally well by increasing the length of the air-gap within reasonable limits. After thus showing that overheating of the armature is sometimes brought about by insufficiency of iron in the teeth, the writer states that it is frequently due to another, not unknown, but often unrecognised cause, especially in small multipolar machines. The loss by hysteresis varies directly as the number of cycles of magnetisation through which the iron passes per second, and the loss by eddy-currents varies as the *square* of the number of cycles of magnetisation per second. Clearly, the periodicity must be kept as low as possible, and herein lies one of the advantages of a slow-speed machine. It is pointed out that the periodicity is affected by the number of poles in the magnet as well as by speed. Therefore it is advisable to have as few magnet poles as possible. Many of the small four-pole enclosed motors now upon the market would certainly run much cooler if the magnets were of the bipolar type. The high periodicity involved by the use of a large number of magnet poles is a more serious matter than it may perhaps appear to be at first sight, for when the watts lost in hysteresis and eddy-currents in the armature stampings amount to from 25 to 50 per cent. of the total armature losses, as they frequently do, it makes quite an appreciable difference in the permissible output of a small high-speed machine to use a four-pole magnet instead of a two-pole one, or a six-pole magnet instead of a four-pole. There is also another reason why the iron losses are greater the greater the number of poles in a machine for a given speed. In order to ensure a sufficient range of sparkless brush movement, the gross polar angle embraced by the poles of the magnet is made less the greater the number of poles on the magnet. The number of teeth embraced by a magnet pole is not exactly in inverse proportion to the number of magnet poles, but is rather less than this—becoming less and less as the number of poles is increased. For this reason, the magnetic induction in the teeth becomes greater as the number of poles is increased. This will not matter much if the radial depth of the teeth is proportionately less, for then the teeth will be proportionately wider at the roots. In conclusion, the writer emphasises the necessity for carefully calculating the watts lost in the armature teeth; so that, in the event of these figuring out too high, the design of the machine may be modified before it is put in hand in the works.—*The Electrician*, Sept. 12th, 1902.

Flow of Steam in Pipes.

AMONG the theses presented at the Virginia Polytechnic Institute, one on the friction of steam pipes is of considerable interest. The introduction explains the general form of the equation for the flow of steam by comparing it with that for water. For the latter, assuming there is no friction h, the loss of head, is equal to $v^2 \div 2g$, by the law of falling bodies. Friction exists, however, varying directly as the length l, and inversely as the diameter d, so that the actual flow is more closely represented by $h = f l v^2 \div 2g d$. Since $2g$ is a constant, this equation can be reduced to the well-known Weisbach expression :—

$$h = f' l v^2 \div d \quad \ldots \quad \ldots \quad (1).$$

As water is practically incompressible, its density is not taken into account, but this must be done when the flow of steam is considered, and the above formula must be modified accordingly. Experiments made under the direction of the Italian Government some years ago showed that the usual formula for the flow of compressible fluids through pipes could be used for steam. This formula is—$Q = c\sqrt{(p d^5 \div w l)}$; where Q equals volume in cubic feet per minute, p equals difference in pressure in lbs. per square inch, d equals diameter of the pipe in inches, w equals density of the fluid in lbs. per cubic foot, l equals length of the pipe in feet, and c equals a constant, of which the numerical value is 58.

By deduction, the author arrives at the following form of equation, where the constant is expressed by the symbol k :—

$$p = k' w l v^2 \div d \quad \ldots \quad \ldots \quad (2).$$

A modification of this formula used by Mr. Babcock, in the computation of the tables issued by the Babcock & Wilcox Company, is the following :—

$$W = 87\sqrt{(w p d^5 \div 1)}\,[1 + (3{\cdot}6 \div d)]\,l \ldots (3).$$

Comparing this formula and that of the Italian authorities, it will be seen to allow for a variation of the constant for different sizes of pipes. Thus, for a 1-in. pipe the constant would be 40·5; for a 3-in. pipe, 58·6; and for a 10-in. pipe, 74·8. The loss caused by a globe valve is stated to be about equal to that in a pipe of a length equal to $114\ d \div [1 + (3.6 \div d)]$. The loss caused by an elbow is two-thirds that due to a globe valve.—*Engineering Record*, Sept. 6, 1902.

The Parsons Steam Turbine.

In a paper read before the British Association Mr. Parsons showed that the steam turbine compared favourably in regard to economy with the ordinary steam engine in the generation of electricity. The steam consumption was generally less, and the running costs, notably the up-keep, expenditure on oil, and the attendance, were also less. There was also generally a saving in first cost of the plant, in the housing, and in the foundations. The lowest consumption so far recorded had been 17·3 lb. of steam per kilowatt hour, with a 1,000-kilowatt continuous-current plant; this corresponded to about 10·2 lb. of steam per indicated horse-power per hour. A still lower steam consumption could be reached in large turbines working with superheated steam and a good vacuum, as the gain due to superheating was equal to 1 per cent. saving in steam for every increase of 10 degs. Fahr. In regard to the question of durability, he stated that several turbine engines had been tested after being at work for a considerable time, and no increase in steam consumption could be detected. Mr. Parsons added that tests had been made with a steam turbine and a Sulzer engine. At three-quarters load the turbine had the advantage; above that the reciprocating engine was best. But the turbine required less oil, the saving amounting in value to about 16 per cent. of the cost of the steam. In the Newcastle central station £5 a week was saved in oil as compared to the amount that would be required in ordinary engines. — *Proceedings British Association*, 1902.

Improved mode of fixing Boiler Tubes.

It has been shown that flaring the tubes of a steam boiler after they have been expanded in place increases the holding power about 300 per cent, and a strong plea is put in for the flaring, as against the mere expanding, of boiler tubes. It has been found that when tubes 3 ins. in external diameter are merely expanded into the tube-sheet it requires a pull of about 6,300 pounds to withdraw them, wheras it takes about 19,700 lbs. to withdraw those which have been expanded and flared. From these data it is shown that a 4-in. tube, running under a pressure of 200 lbs. per square inch, and merely expanded into place, has a factor of safety about of 2.5, which is considered to be entirely too small. With the tubes properly flared, the factor of safety under like conditions would be 7.8, which is considered to be quite large enough. While it is admitted that there are many water-tube boilers that are running satisfactorily to-day with tubes that are merely expanded into place, it must be remembered that there has been a great rise in pressures of late years, and that constructions which may have been thoroughly up to the standard fifteen or twenty years ago are considerably below it in this day of pressures of 200 lbs. to the square inch and upward. These conditions, we think, should render the practice of flaring the tube ends an indispensable feature of first-class modern boiler construction.—*Scientific American*, Sept. 6, 1902.

The De Laval Steam Turbine.

Mr. J. E. Coleman, M.E., describes a series of tests conducted with a 300 h.p. De Laval turbine engine at Trenton, N.J. The distinctive features of the De Laval turbine are to be found in the form of the nozzles, designed to promote adiabatic expansion of the steam; a flexible shaft on which the turbine wheel is mounted, and double helical spur gears which connect the turbine shaft with the working shaft. In the turbine tested the diameter of the wheel was about 30 inches Steam was supplied through eight nozzles, any of which could be closed by means of cocks according to the load. A modification of the fly-ball governor regulated speed by throttling the entering steam, and the engine was connected to a jet condenser. The tests included a series of four runs, and the steam consumption per brake horse-power per hour was found to be as follows:—Full load 14·33 lbs., three-quarter load 15·04 lbs., half-load 16·57 lbs. and three-eighths load 17·66 lbs. The steam consumption at three-eighths load is about 23 per cent. greater than that at full load; this variation is not large, and it is safe to say that it would have been much less if the steam had been superheated throughout as it was for the full-load run. Expressing steam consumption of the turbine in lbs. per 1 h.p., as given for reciprocating engines, the weight is 12·5 lbs. per 1 h.p. per hour at full load, which, considering the size of the turbine tested, is remarkably good.—*Power*, Sept. 1902.

REVIEWS.

Experimental Engineering. Vol. II. A Treatise on the Methods and Machines used in the Mechanical Testing of Materials of Construction. By William Charles Popplewell, M.Sc., A.M.Inst.C.E. (Manchester: The Scientific Publishing Co.)

We are ready to agree with the remark of the author in his preface that "little apology is needed for the existence of this book," for the reason that intimate acquaintance with the physical and mechanical properties of materials employed in engineering work is more than ever necessary to the professional man. The student of such a work must naturally possess a sufficient knowledge of the principles of mechanics, and especially of that part relating to stresses and strains, otherwise he will be unable to interpret the results afforded by experiment. Although the author assumes that his readers are not to be classed as absolute novices, he has thought it desirable to devote one chapter to a summary of the chief problems arising out of the phenomena displayed by bodies under various stresses. The chapter in question is mainly definitive, and in it we find statements illustrated by diagrams, as to the nature of elasticity and plasticity, stress and strain, external and internal stresses, compound stresses, the relation of stress to strain, Poisson's ratio, cubic elasticity, bending, the deflection of beams, stresses and strains in the plastic state, and the flow of metals. By the aid of this explanatory matter, the student may familiarise himself with the principles underlying the phenomena exhibited by bodies under loads, and so be, to some extent, prepared for following the author in his description of the appliances and methods used in testing operations.

With Chapter II. the author starts in earnest upon the task set before him, and in a few preliminary remarks he usefully points out that in what is termed "commercial" testing, most specimens are tested to destruction, whereas in scientific research forces are very frequently applied so as to produce only elastic deformations, which can therefore be repeated as often as may be desired. In the former case the observer is enabled to gain, for a specific purpose, sufficient knowledge of the practical strength of the material under examination, and in the latter he has facilities for studying the inherent properties of the material. Although this chapter is entitled "Testing Machines," the heading is somewhat misleading, for the author does not consider all the types of testing machines required by the investigator. The simplest form of apparatus used for a tension test, is one where the specimen is firmly attached to a rigid support and the loads are applied in the form of deadweights to its lower end. Such an arrangement may be suitable when little tensile stress is involved; but as it would be inconvenient to deal with deadweights of any magnitude in this manner, other means of applying force become necessary. In all the larger testing machines used in this country, hydraulic power is employed, as the author rightly says, "on account of its great capability of being easily controlled, and by reason of its greater efficiency as compared with screw gearing." The latter mode of applying force, used in many of the smaller machines, may consist of a direct-acting screw or a worm wheel rotated by a worm and acting as the nut on a fixed screw; but it is pointed out that the mechanical efficiency of such an arrangement is extremely low, and that the practical limit of load that can be applied by manual power is not more than two or three tons. For loads beyond this value steam and other mechanical power must be employed.

In classifying various testing machines of the kind under consideration in the present chapter, the writer is guided by the manner in which are arranged the weighing appliances for measuring the magnitude of the load. Thus there are (1) Single-Lever Machines, (2) Multiple-Lever Machines, and (3) Manometer or Fluid Pressure Machines. Illustrations and examples of each class are then given, and the author goes on to describe in detail a large number of testing machines, such as the Werder, the Buckton-Wicksteed, the Adamson, the Greenwood, the Cardiff, the Bailey, all but the first named being made in this country, and varying from small capacity up to 1,000,000 pounds. Continental and American machines next receive attention, amongst those singled out for separate mention being the Grafenstaden, the Thomasset, the Emery, the Fairbanks, the Ohlsen, and the Ritchie testing machines. The concluding portion of the chapter is devoted to a comparison of various types of testing machines; and this part of his subject is approached by the author in a particularly fair and unbiassed manner. He shows that such appliances are used for so many purposes and under such varied conditions that it is not possible to say definitely that "one testing machine, or one type of testing machine, is better than another."

Testing work varies to such an extent that the qualities specially recommending a particular machine for certain experiments may not be advantageous for other experiments of a kindred nature. Nearly every investigator has his pet machines and appliances; he has learnt the merits, and perhaps the demerits of these, and he feels thoroughly at home with them. Consequently he is apt to fancy that other tools are less reliable, or, at any rate, are less convenient. Hence there are very few men capable of expressing a really reliable opinion as to the comparative merits of well-designed testing machines of any particular class. Mr. Popplewell wisely contents himself with an enquiry into the qualities possessed, to a greater or less degree, by all such apparatus, leaving his readers to decide for themselves the most suitable examples for adoption. Simplicity is much to be desired for various reasons, yet its attainment is largely prevented by the fact that a testing machine, and especially a large one, must be made to suit experimentalists who demand facilities for variations of load, as well as for a considerable variety of tests upon specimens of different sizes, and with different kinds of stresses. From the point of view of convenience, ease of access to the specimen, convenience of manipulation, and adaptability are the features chiefly desirable. Sensitiveness is closely allied to accuracy, though of course the two qualities are distinct. While on the subject of sensitive-

ness, Mr. Popplewell mentions some interesting facts. For instance, he tells us that in the course of experiments by Professor Kennedy on a Greenwood machine that had been used for over 12,000 tests, it was found that the increment of load required to produce a movement in the last lever was from 1/1250th to 1/5555th of the total load at 5,000 and 50,000 lb. loads respectively. Again, he mentions that Mr. Wicksteed illustrated the practical absence of friction of a good knife edge by breaking 12 pieces of No. 16 cotton, at the average breaking load of 3·5 lb., and 12 No. 12 threads at the average load of 3·8 lb. Pieces from the same reel were then broken by the application of dead-weights at precisely the same loads. The delicacy of fluid-pressure machines is illustrated by an Emery machine, in which a test specimen was broken at a load of 90,000 lb., and immediately afterwards a horsehair was placed in the machine, and broken at the small load of 1 lb. Mr. Adamson, a few years ago, mentioned the fact that the recording lever of his machine was sensibly affected by differences in the temperature of a test bar in the machine caused by simply placing his hand upon the metal. As the author truly remarks, these few instances "show that a degree of sensitiveness exists in most machines, which is safely in excess of the requirements of even the most refined tests that are made." Accuracy cannot be more than a relative term, but there are many avoidable sources of error. For instance, error may be due to inaccuracy of the distances between the knife edges, and variation of distance may be due to faulty construction, or to wear. Incorrectness of the weights may be a direct source of error; stresses may be occasioned, but not indicated, by inertia forces due to movement of the machine parts; and deflection of the levers may account for inaccurate readings. Finally, the centres of gravity of the levers and weights carried thereon may be so disposed as to result in angular displacements of the beam, thus causing small errors. In summarising the above points, the author again advises his readers to draw their own conclusions, but his personal preference is clearly for the Buckton-Wicksteed testing machine.

Auxiliary Measuring Appliances are described in Chapter III., these being for the purpose of taking linear measurements of the test specimens, both before, during, and after a test. Instruments of the kind are of two main classes—(1) those for taking the dimensions of specimens before and after the test, as well as the approximate measurements taken during the test and, (2) those employed for minute measurements during a test and while the material is in the elastic state. One of the most useful instruments is the ordinary steel rule, used in conjunction with spring or screw-clamp dividers, but as most metal test pieces have to be measured to thousandth parts of an inch, the vernier caliper and the micrometer screw caliper become necessary. Measurements to ten-thousandths or smaller parts of an inch are rarely required, but can be made by what are termed "measuring machines." These have been made capable of indicating differences down to the millionth part of an inch—a measurement difficult to imagine and fully as difficult to perform. For practical work, a more suitable machine is one capable of taking measurements in ten-thousandth parts of an inch, one of its chief uses being the calibration and checking of other measuring instruments. Extensometers are instruments made in considerable variety, and intended for the measurement of strains produced during testing operations. Mr. Popplewell gives an excellent description of the principal forms of extensometers, each type being illustrated by one or more diagrams, and a useful summary of their chief characteristics is given at the end of the chapter. We now come to several chapters devoted to Testing Operations, where different kinds of tests are fully discussed. The tensile test is more frequently made than any other, and is performed upon nearly all the materials of construction, the most notable exceptions being brick, stone, and kindred substances. In his previous description of testing machines, the author purposely omitted particular mention of the methods and devices used for holding the ends of tension specimens, and he now proceeds to describe these in detail, with the aid of drawings showing the grips, and also the most suitable forms for test specimens. Then follows an explanation of all the operations involved in a complete tensile test, the subject being a bar of steel 18 ins. long by 1 in. diameter. In what is termed "commercial' testing, it is unnecessary to ascertain all the measurements and results described by the author, but the student must be familiar with the methods by which they are to be found. Compression tests are treated in somewhat similar fashion, and the author then passes on to consider Shearing and Bending Tests, as they are called in the heading, though the latter come under the sub-title of Cross-Breaking Tests, in the body of the chapter, an apparent discrepancy that may at first sight tend to confuse the student. The next portion of the subject is that dealing with Twisting and Torsion Tests, which yield much more reliable information than tests in direct shear. In this chapter we find illustrations and descriptions of testing machines not included in Chapter II. It is certainly an advantage in a work of the kind now under review that everything should be classified in the most thorough manner, and if the author finds a reason for omitting certain parts of a subject from the chapter professing to deal with it completely, it would be well to make a corresponding modification of the title. Apart from this suggestion we have no fault to find with the chapter, which is really one on Tortional Testing Machines and Torsion Tests. The author illustrates a variety of testing machines, and points out the respects in which some of their details might be improved. He explains the principles applicable to the measurement of torsional strains, and elucidates his teaching by following the complete test of a mild steel bar in torsion. For the results of tests, such as those hitherto mentioned, the diagram forms a most convenient record, and in his next chapter Mr. Popplewell gives an excellent *résumé* of several ingenious appliances designed for the production of auto-

graphic diagrams, traced, as the test proceeds, by a pencil connected with the specimen itself. It is by no means an easy task to design a really satisfactory autographic apparatus, and that devised by Professor Kennedy is considered by the author to represent one of the most successful attempts. This instrument is perfectly automatic, and quite independent of manipulation by the operator, but it is of somewhat delicate character. Mr. Wicksteed has designed a simpler form of apparatus which is also truly automatic and accurate within certain limits. Other instruments for the tracing of diagrams come under the heading of Semi-Automatic Recording Apparatus, of which some varieties are described, including those of Professor Unwin, and Messrs. Riehlé Bros. The student will find some most interesting examples of autographic diagrams in the chapter, together with practical instruction as to the uses and limitations of such records. Still pursuing the general subject of Testing Operations, the author touches extremely practical matters in Chapter VIII., where detailed treatment is accorded to the testing of wire ropes; the testing of wire by tension, torsion, and repeated bendings; the testing of fibrous ropes; the testing of metals at high and low temperatures; the testing of chains; tests for the hardness of metals; and finally, under the sub-heading of Shop Tests of Iron and Steel, instructions are given for the performance of hot and cold bending tests, drifting tests, drop tests, and smithy tests. Special machines for wire testing are also illustrated in the same chapter, which is evidently intended to serve "practical," more particularly than "experimental," purposes. Chapter IX., devoted to the Testing of Struts or Pillars, is excluded from the series on Testing Operations, although not less appropriate therein than some of the chapters previously mentioned. The greater portion of the chapter is occupied with a brief dissertation on the principles underlying various formulas that are supposed to express the relation between the dimensions of pillars and the loads required to produce failure. Two chapters now occur tending to divert the mind of the reader from testing operations pure and simple. These relate to General Phenomena Exhibited by Test Pieces under Varying Conditions, and to Experiments on the Relation of Stress and Permanent Strain and on Repeated Stresses. The facts contained in these instructive chapters are familiar to students of works upon the materials of construction, and require no special comment. Following them we have a short chapter on the Testing of Vitreous Materials and Timber, largely devoted to the important subject of testing Portland cement; and the volume is brought to a conclusion by a series of data as to the Strength Properties of the Principal Materials of Construction. Considering the work as a whole, it must be regarded as a successful attempt to make clear the essential mechanical principles involved in testing work; to familiarise the reader with the appearance, construction, and qualities of different testing appliances, as well as with the most advantageous methods of using such aids; and to furnish reliable information as to the results already obtained by leading experimentalists. The volume is certainly one that will be of great value to students, and not without its uses for those who have occasion to employ the materials of engineering construction in actual practice.